Improving Livestock Production in Africa

Evolution of ILCA's programme 1974–94

International Livestock Centre for Africa (ILCA)

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Evolution of ILCA's programme 1974–94

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Foreword

The International Livestock Centre for Africa (ILCA) came into being in 1974, twenty years ago.

In light of the forthcoming incorporation of ILCA into the new International Livestock Research Institute (ILRI), we have developed this publication, which documents the evolution of ILCA's programme over the last two decades. This evolution was punctuated by the external reviews of the Centre, commissioned every five years by the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR).

While many other factors influenced the development and evolution of the Centre, not least its Directors General, members of the Board of Trustees and its staff, the quinquennial reviews had the most immediate and well-documented influence on major changes in direction. Each review made recommendations that the Centre had to respond to, whether in modifying its structure or activities or in rebuttal.

The chapters in this book correspond to the periods between these reviews, and the main features of each of these periods can be characterised as follows:

Chapter 1: Origins and mandate. This chapter provides the background to the establishment of the Centre, focusing on the reports of the two "task forces" whose recommendations led to the founding of ILCA.

Chapter 2: The early years: Focus on systems descriptions. This chapter covers the period up to the first external review of ILCA in 1981. ILCA was set up in the belief that the solutions to livestock production problems were already available, but knowledge of African production systems was lacking. The early years of ILCA thus emphasised system studies that described the major agro-ecological zones of sub-Saharan Africa and their production systems.

Chapter 3: Systems description and component research: ILCA's programme matures. This chapter covers the period between the first external review and the second, which was carried out in 1986. This period saw the evolution of ILCA's programme, with increasing emphasis on component research within the systems described during the first phase.

Chapter 4: A new focus to ILCA's research. The second external review of ILCA identified a need to focus the Centre's programme. This coincided with moves in the CGIAR system, instigated by TAC, to five-year programmes and budgets for the centres. ILCA responded by developing its Strategy and Long-term Plan, followed by the Centre's first medium-term plan, covering the period from 1988 to 1993.

Under the medium-term plan, ILCA's research programme was realigned into thrusts, reducing the emphasis on agro-ecological zones as the basis of research planning and operational organisation. This allowed for greater linkage of research efforts between zones and the identification of common production constraints requiring common approaches. Goal-oriented Project Planning (GOPP) was used to develop and refine the Centre's research priorities and programme, with greatly increased emphasis on strengthening national agricultural research systems (NARS) through training and networking.

Chapter 5: The Second Medium-term Plan, 1994–98. This chapter reports on the development of ILCA's second medium-term plan for 1994–98. This built on the experience gained with the first medium-term plan, together with the continuing need for focus identified by the third external review of the Centre in 1992, and emphasised research excellence. Other major influences on the plan included the TAC strategy and priorities paper of 1992 and Winrock International's Assessment of Animal Agriculture in Sub-Saharan Africa. The second medium-term plan represented a further evolution of the Centre's programme, with increased emphasis on strategic research in nutrition, health and genetics; and increased attention to impact assessment, and policy, socio-economic and ecological research.

Implementation of the plan was largely overtaken by the events that led to the establishment of ILRI.

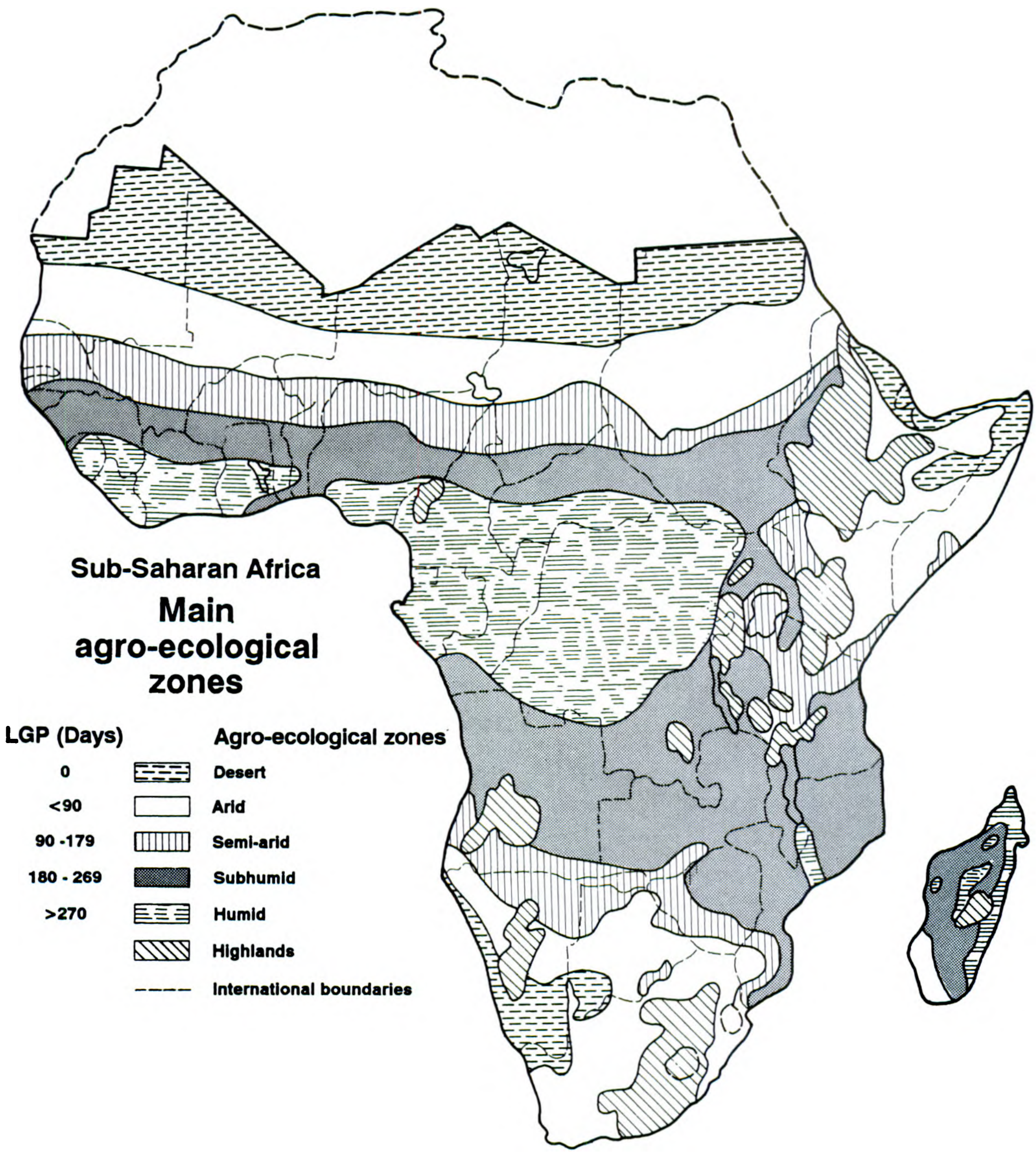
Chapter 6: Moves towards a global livestock research institute. This chapter charts the moves by the CGIAR towards the establishment of ILRI as the global livestock research entity within the CGIAR system.

Following this structure for the book also had some consequences for the presentation of the programme. Up to the first medium-term plan in 1988 the Centre's main programme structures were the zonal research programmes. Under the 1989–93 medium-term plan, the Centre's programme was structured by the six research thrusts, each of which had five "themes". In describing the programme, we have picked a few pieces of research in each area that provide a picture of the evolution and progress of the Centre's research. But in 1987 there were only six major "pigeon holes" (the zonal research sites) to be filled, while in 1988 and subsequent years there were some 30 (six thrusts by five themes). This has resulted in Chapter 4 being considerably larger than the earlier chapters. This is not intended to indicate that more was done during this period of the life of the Centre, but is a consequence of the structure we have imposed on ourselves.

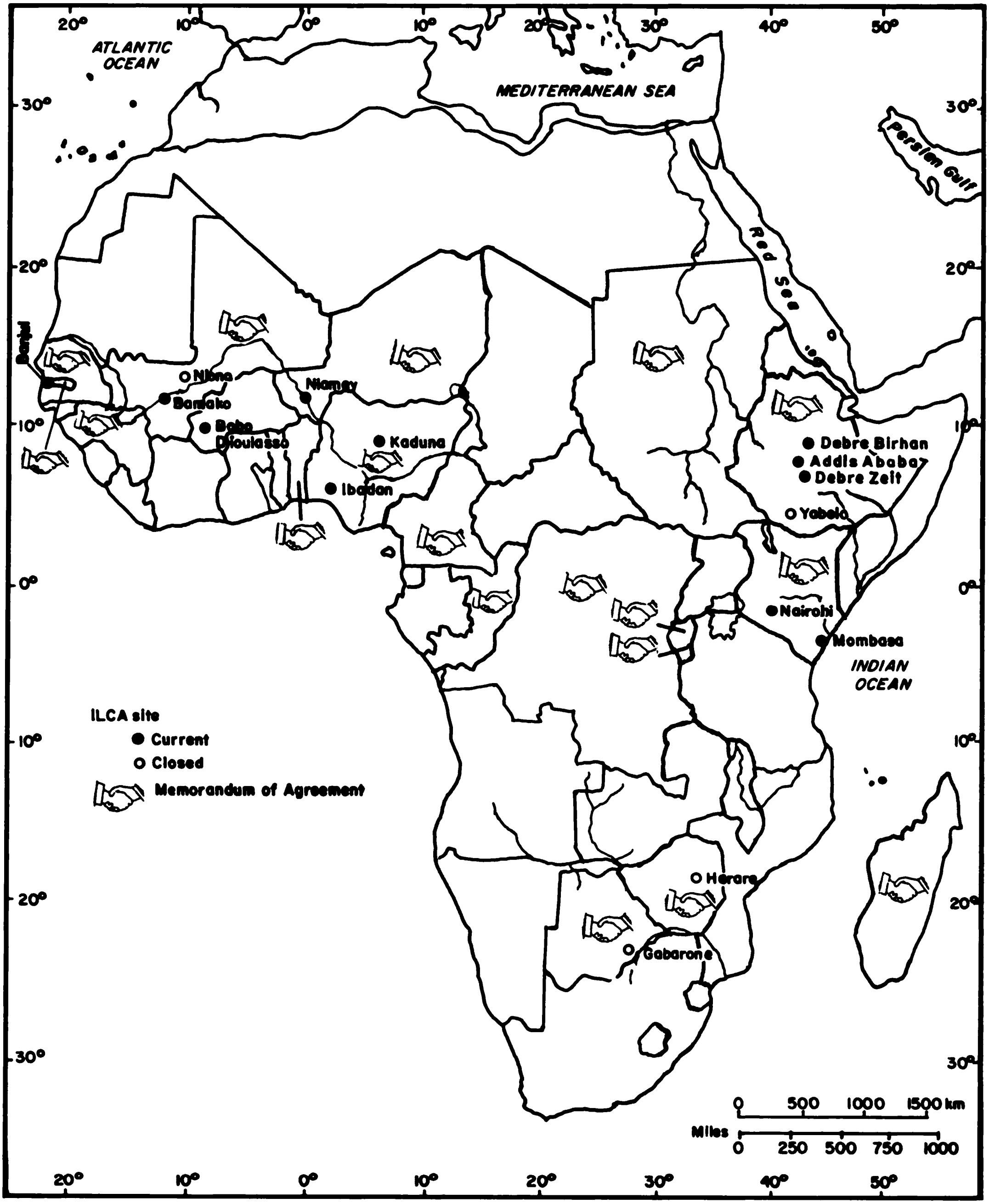
We trust that readers will find this book useful and that it will provide a record of twenty years' achievements by ILCA in the service of livestock research in sub-Saharan Africa.

Dieter Bommer	Hank Fitzhugh
Chairman	Director General
ILCA Board of Trustees	ILCA

Agro-ecological zones of Africa



ILCA in Africa



Important mile-stones in ILCA's history

1969

April	First Bellagio Conference

1970

February	Second Bellagio Conference
April	Third Bellagio Conference *Discussed formation of CGIAR* *Requested feasibility study on key areas, including livestock in Africa*

1971

January	CGIAR established
June–July	First TAC meeting, Rome
October	Beck Committee Report: "An International African Livestock Centre — Task Force Report"
	Second TAC meeting discusses Beck Report *Recommends second Task Force study*
December	Second meeting of CGIAR. Creation of Sub-Committee on African Livestock Research

1972

April–Sept	Tribe team assesses need for a livestock production research centre in Africa

1973

March	Fifth TAC meeting. Second Task Force Report (Tribe Report) presented and endorsed
June	CGIAR Sub-Committee on African Livestock Research selects most members of ILCA's founding Board of Trustees
October	First meeting of the ILCA Board of Trustees, London, UK
	Dr R. Hodgson elected Chairman of Board of Trustees
November	CGIAR meeting informed of progress towards establishment of ILCA and ILRAD

1974

January	Second meeting of the ILCA Board of Trustees, Addis Ababa, Ethiopia
	Dr J. Pagot (France) designated Director General of ILCA
May	First meeting of Executive Committee of the ILCA Board of Trustees
July	Memorandum of Agreement signed between ILCA and the Government of Ethiopia
September	Revolution overthrows Government of Ethiopia Dr Pagot takes up duties in Addis Ababa First staff recruited
November	Meeting of Programme Committee of the Board of Trustees discusses ILCA strategy

1975

April	Meeting of Programme Committee of the Board of Trustees discusses ILCA strategy
	Library established and collection of documentation started
May	Ethiopian Council of Ministers ratifies Memorandum of Agreement; ILCA established as a legal entity
	Contract signed with an architect firm for the design of the headquarters buildings

1976

	ILCA signs 99-year lease with the Ethiopian Government for the land on which the headquarters will be built and construction starts
January	Memorandum of Agreement with the Government of Mali signed
	Semi-Arid Zone Programme established in Mali
	Ethiopian Government makes available land for a research station at Debre Zeit, Ethiopia
	Research starts in highlands and semi-arid zone, Ethiopia
August	Memorandum of Agreement with Government of Kenya signed
	ILCA office established in Nairobi, Kenya
December	Dr J. Pagot resigns as first Director General of ILCA

1977

	Ad interim direction of ILCA assumed by Prof D. Tribe and Mr D. Pratt (Board members) and Dr R. Temple (ILCA staff)
	Training programme starts
March	First TAC mission to ILCA
July	Memorandum of Agreement with Government of Botswana signed
	Botswana project established
November	Memorandum of Agreement signed with Government of Nigeria regarding work in the forest belt (humid zone) and in the savannah belt (subhumid zone)
December	Mr D. Pratt (UK) appointed Director General of ILCA

1978

	Subhumid Zone Programme established at Kaduna, Nigeria
	Humid Zone Programme established at IITA, Ibadan, Nigeria
April	Mr Moise Mensah (Benin) elected Chairman of Board of Trustees
December	First Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, ILCA headquarters, Addis Ababa, Ethiopia
Nov 1978 – April 1979	Second TAC mission to ILCA

1979

	Ethiopian Government makes available land for a research station at Debre Birhan, Ethiopia

1980

September	Revised Memorandum of Agreement with Government of Mali signed
October	ILCA headquarters building inaugurated by President Mengistu Haile Mariam
	Prof R. McDowell elected Chairman of Board of Trustees
	African Trypanotolerant Livestock Network established by ILCA and ILRAD

December	Mr D. Pratt leaves ILCA

1981

January	Second Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, ILCA headquarters, Addis Ababa, Ethiopia
	Dr P.J. Brumby (New Zealand) appointed Director General of ILCA
	African Research Network on Agricultural Byproducts (ARNAB) established
Sept–December	First TAC Quinquennial Review of ILCA

1982

December	Memorandum of Agreement with the Government of The Gambia signed

1983

July	Memorandum of Understanding with the Institut d'élevage et de médecine vétérinaire des pays tropicaux (IEMVT) signed, which enabled secondment of IEMVT staff to ILCA
	Forage Network in Ethiopia (FNE) formed
December	Memorandum of Agreement with the Government of Niger signed
	Botswana project closes

1984

February	Memorandum of Agreement with the Government of Benin signed
August	Memorandum of Understanding with the Comité inter-Etats de luttes contre la sècheress au sahel (CILSS) signed
October	Third Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, ILCA headquarters, Addis Ababa, Ethiopia
November	Memorandum of Understanding with Winrock International signed

1985

February	Memorandum of Agreement with the Government of Senegal signed

March	Memorandum of Agreement with the Government of Rwanda signed
April	Dr Barry Nestel (UK) elected Chairman of Board of Trustees
May	Memorandum of Understanding with the Organization of African Unity signed
	ILCA/ILRAD project in The Gambia and Senegal established, based at the International Trypanotolerance Centre in The Gambia
	African Livestock Policy Analysis Network (ALPAN) and Pasture Network for Eastern and Southern Africa (PANESA) established

1986

June	Reports of First External Management Review and Second External Programme Review of ILCA presented to TAC
	Memorandum of Agreement with the Government of Congo signed
November	Dr P. Brumby leaves ILCA
December	Dr J. Walsh (Ireland) appointed Director General of ILCA

1987

May	Dr R.W. Cummings (USA) elected Chairman of ILCA Board of Trustees
June	Draft ILCA Strategy and Long-term Plan submitted to TAC
July	Fourth Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, ILCA headquarters, Addis Ababa, Ethiopia

1988

August	ILCA/Kenya Agricultural Research Institute (KARI) collaborative programme established at KARI's Mtwapa Regional Research Centre near Mombasa, Kenya
September	Memorandum of Agreement with the Government of Sudan signed
October	ILCA's first medium-term plan (1989–93), *Sustainable Production from Livestock in Sub-Saharan Africa*, presented at International Centers Week

	Cattle Research Network for West and central Africa established
December	First joint ARNAB/PANESA Workshop

1989

February	Alley Farming Network for Tropical Africa (AFNETA) established in collaboration with IITA and ICRAF
March	Memorandum of Agreement with the Government of Guinea signed
May	Memorandum of Agreement with the Government of Cameroon signed
June	Cattle Research Network for East and southern Africa established
September	ILCA Semi-Arid Zone Programme in Niger established, based at ICRISAT Sahelian Centre
October	Fifth Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, ILCA headquarters, Addis Ababa, Ethiopia
	Memorandum of Agreement with the Government of Zimbabwe signed

1990

October	Memorandum of Understanding with the Communauté économique des Etats de l'Afrique de l'Ouest (CEAO) signed

1991

February	Memorandum of Agreement with Government of Zaire signed
March	African Feed Resources Network (AFRNET) formed from merger of ARNAB and PANESA
	Revised Memorandum of Agreement with the Government of Ethiopia signed
May	Prof Dieter Bommer (Germany) elected Chairman of Board of Trustees
	Memorandum of Agreement with Government of the Malagasy Democratic Republic signed
	Ethiopian Government overthrown
August	ILCA opens Regional Facilitation Office for Eastern and Southern Africa in Harare, Zimbabwe

October	Sixth Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in sub-Saharan Africa, ILCA headquarters, Addis Ababa, Ethiopia
	ILCA/ILRAD project in The Gambia and Senegal concluded

1992

February	Project on conservation of African animal genetic resources launched
March	Third External Programme and Management Review of ILCA reported to TAC
July	Memorandum of Agreement with the Government of Burundi signed
August	ILCA opens Regional Representation Office for West and central Africa in Bamako, Mali

1993

March	ILCA's second medium-term plan (1994–98), *Sustainable Production from Livestock*, presented to TAC
May	CGIAR establishes Steering Committee on Livestock Research, chaired by Dr Lucia Pearson de Vaccaro
July	Dr J. Walsh leaves ILCA
August	Dr Hank Fitzhugh (USA) appointed Director General of ILCA
October	Steering Committee proposes Centre for International Research on Livestock
	ILCA Board of Trustees endorses Steering Committee proposal
	Dr Neville Clarke (USA) elected to succeed Dr Bommer as Chairman of Board of Trustees
	CGIAR approves Steering Committee proposal
	Rockefeller Foundation designated as the Implementing Agency to manage the establishment of new centre
November	Mr Robert Havener (USA) appointed by Rockefeller Foundation to coordinate the process on its behalf

1994

	Implementing Advisory Group established, chaired by Dr Neville Clarke (USA)
	Strategic Plan Task Force established, chaired by Prof Patrick Cunningham (Ireland)
June	Draft strategy and medium-term plan reviewed by TAC
	Memorandum of Consultative Agreement signed with UN Economic Commission for Africa (ECA)

Chapter 1

Origins and mandate

The idea of an international centre designed to help improve livestock production in Africa was first discussed in 1968. The initiative was taken by the Rockefeller Foundation, which, with the Ford Foundation, had been instrumental in establishing the first of the international agricultural research centres. The early centres had focused on cereal production and had produced the high-yielding crop varieties which led to the Green Revolution. The question now raised was whether a new centre could contribute a similar impetus to livestock production in Africa.

Following a series of meetings between 1968 and 1970, the Rockefeller Foundation organised a task force which toured tropical Africa in 1971 to examine the need for and possible role of an international livestock centre for Africa. The task force was led by Professor G.H. Beck and drew on the advice and services of a substantial number of contributors. At the same time, the Consultative Group on International Agricultural Research (CGIAR) was established to broaden and continue the work started by the Ford and Rockefeller Foundations in the field of international agricultural research. Thus, the report of the task force was submitted by the Rockefeller Foundation to the CGIAR, with the recommendation that an African livestock centre be established similar in concept and organisation to the existing centres.

The report of this task force began the process that would shape the philosophy of the new centre, stressing the need for research on livestock production systems in Africa:

> *"The most important function of the Centre would be to assemble a multi-disciplinary team of scientists to develop research programs designed to solve the basic production and socio-economic problems that are serving as constraints to livestock development. . . . A study of livestock production systems of Africa is an area of high priority. New research is likely to have most impact if planned within the context of these production systems. An Analysis and Planning Unit would be required from the inception of the Centre for this purpose. This would involve surveys and data analysis covering sociology, range ecology, water resources, animal production, economics and marketing."*

The CGIAR was attracted by the concept of such a centre, but considered that further study was needed on several issues. A second task force was therefore organised in 1972 under the leadership of Professor D.E. Tribe, from Australia. Its focus was specifically on livestock production, since the CGIAR was already, by this time, anticipating the establishment of the International Laboratory for Research on Animal

Diseases (ILRAD) with a mandate for research on the immunology of specific animal diseases.

The report of the second task force in large part influenced the shape of ILCA in its early years, in particular the emphasis on "systems research". The task-force report states:

"The main impediment to development is not merely the lack of technical knowledge. A considerable fund of knowledge has resulted from several decades of work at numerous research centres.... Although the results of much of the past work are not widely known ... the primary cause of the disappointing growth in animal productivity in tropical Africa has been the failure to integrate the biological, economic and sociological components of research and development programmes.

"In particular there is a need for more detailed study of animal production systems of tropical Africa before existing knowledge can be fully utilized or future research priorities defined. This work must give full consideration to those aspects of biology, economics and social anthropology that relate to animal production."

Elsewhere, the report states:

"... there is ample evidence to show that the application of known technology would considerably increase present African livestock production."

These beliefs are reiterated throughout the report.

"It has already been emphasised that technical answers are available to many of the specific problems facing livestock development of Africa. The major constraint lies rather in the difficulty of introducing change into existing socio-economic systems, combined with inexperience in adapting technologies to suit local situations.

"The first task of the interdisciplinary team would be to gain a basic appreciation of the major livestock production systems of Africa, by the study of all available literature, a review of ongoing research programmes, and widespread travel and survey. From this base the team will then be expected to devise its own programme of studies.

"Having established broad frameworks for systems studies, it is anticipated that a more analytical phase will soon follow, which will both identify areas of specific ignorance which deserve priority attention in future surveys and research, and suggest new or amended systems of animal production. This research effort will concentrate on techniques of rangeland management, livestock production, disease control and marketing which could be incorporated in future development schemes. Such techniques and systems will almost certainly require validation and further

investigation, either at the Centre itself or within a cooperative programme at national stations, so that a constant interplay can be expected between research and development planning.

"Emphasis initially should be given to studies of those societies which at present own most of the livestock, but with the objective of expanding, as soon as possible, to embrace a wider range of agricultural and commercial systems.

"It will also be important to examine the response of traditional systems to development processes. Indeed, the monitoring of ongoing development programmes needs to receive a high priority, since these programmes represent unique experiments which can never be reproduced in the confines of a research station. . . . At first these studies are likely to be mainly in eastern Africa, where existing development programmes already affect a wide range of pastoral societies, though they would be selected also for their wider relevance to Africa as a whole."

This was not based on the beliefs of Task Force members alone but drew on a number of earlier reports. In Annex III to the Task Force report, Professor Tribe quotes Pino (1970) as referring to "the prevailing complex cultural systems of the African countries" and anticipating an international animal research institute that would accomplish its aims by "compiling and testing existing knowledge leading to economic beef cattle production systems."

Similar views were expressed by Fransen et al (1970), who emphasised that:

"the activities of the proposed International Livestock Research Centre should not be restricted to the technical aspects of increasing livestock production. At the outset, these should be integrated in a 'systems approach', embracing sociology, marketing, pricing, credit and land tenure. . . . Such research should be aimed at the applied aspects of ranch development and not at the accumulation of detailed scientific data; in brief the goal should be to increase the financial viability of the different systems and to improve the social wellbeing of communities."

The proposed shape of the Centre

The Tribe Task Force identified a range of activities that the new centre should engage in. Specific terms of reference set out included:

- to retrieve, assemble and make available in both English and French all relevant information on animal production in tropical Africa
- to engage a multidisciplinary research staff to study existing animal production systems and to develop new or amended methods of production and define priorities for other research

- to support, supplement and cooperate with existing national and regional research stations or programmes in developing a fully coordinated programme of production and rangeland research related to the urgent needs of livestock development
- to develop the capacity to undertake research programmes in specific aspects of livestock production appropriate to an international centre
- to organise or assist in organising seminars, technical conferences and training courses for staff engaged in livestock research, extension, planning and production, in order particularly to increase regional competence in the interdisciplinary systems approach to livestock research and development
- to make available statistical support, information or advice to national, regional or international authorities in the various fields relating to animal production in which the Centre is actively engaged.

The Task Force stressed that the new centre was not to work in isolation from national programmes in Africa.

"In all of these activities, the Centre should seek every opportunity of cooperation with existing institutions in Africa. The ultimate success and effectiveness of the Centre will depend upon its influence through the activities of national and regional institutions rather than directly through its own activities."

It also stressed the need for the centre to establish its credentials and credibility through its own programme of work:

". . . In order to be influential the Centre must achieve an appropriate status and identity of its own, but it should not put itself into competition with existing institutions. Its essential role should be complementary, cooperative and catalytic."

These views helped shape the centre recommended by the Task Force. The Task Force concluded that what was needed was a decentralised centre which could give the maximum amount of help to national centres. The help envisaged by the Task Force was in terms of scientific leadership, policy guidance, research training, scientist-to-scientist cooperation and specific project support where the centre had identified critical areas where knowledge was lacking.

But, as the Task Force noted:

". . . for an international centre to assume this type of leadership role, and for this role to be recognised and acknowledged by national staff and institutions, the centre must first earn for itself a reputation for proven and practical ability and achievement. Therefore there must be a sufficient capacity at the headquarters of an international centre for its research, documentation, and training staff to establish for themselves the reputation for excellence which is an essential basis for an extensive programme of cooperation with national institutions."

This vision led to the recommendation of the initial shape of what was to become ILCA, with an emphasis on a strong headquarters programme and a number of "satellite" programmes:

> *"... we have envisaged a centre which includes a strong headquarters with a network of co-operative programmes (including outposted staff) on national research stations. The "nerve centre" will provide much needed leadership and support for national research efforts by means of its integrated research, training and information activities. However, to be effective there will need to be, in addition, the project programme of co-operative research based on national research stations. It is envisaged that these projects will be part of the systems research programme of the centre and that they will be carried out by outposted centre staff with centre finance."*

The report of the second task force was considered by a subcommittee of the CGIAR and its newly formed Technical Advisory Committee (TAC) and was accepted in August 1973. The World Bank was designated as the executing agency with responsibility for establishing the centre. The International Development Research Centre (IDRC), Canada, agreed to work with the Bank during the establishment period and to provide financial support for the initial activities of a Board of Trustees and a project development officer.

Location of the Centre

The Tribe Task Force deliberated at some length on where the headquarters of the new centre should be located. They laid out the ideal location as having the following attributes:

- Ready accessibility to an international airport which has good connections to East, central and West Africa.
- Proximity to a population centre which enjoys a tolerable climate and provides reasonable amenities to staff members and their families (shopping, education, health services and entertainment).
- Desire on the part of the host country to have the Centre and willingness to provide tax and import concessions and other privileges appropriate to an international centre.
- Availability locally of trained personnel sufficient to provide the required supporting scientific, technical, administrative, clerical and domestic staff.
- A social and educational environment that would readily accommodate French- and English-speaking people and which could provide bilingual support staff.
- Proximity to a range of ecological conditions, diverse animal production systems and ongoing schemes of livestock development.

- Availability of field research facilities within a reasonable distance of the Centre's headquarters.
- Proximity to a university which has active programmes of study in agricultural economics, sociology, agriculture and veterinary science.

Several locations were identified and seriously considered by the Task Force, including Abidjan (Côte d'Ivoire), Addis Ababa (Ethiopia), Dakar (Senegal), Kampala (Uganda), Nairobi (Kenya), Yaounde (Cameroon) and Zaria (Nigeria). The Task Force's recommendation was that the Centre be located in Addis Ababa or, if the CGIAR wished to establish the Centre in West of central Africa, Yaounde.

The Task Force gave its reasons for this as follows:

"Addis Ababa has a large expatriate population and is the headquarters of the ECA [United Nations Economic Commission for Africa] and the OAU [Organization of African Unity]. It has a cool and healthy climate although the high altitude (2500 m) does not suit everyone. It already has the best air connections to other African cities and these are improving further. It possesses the best schooling facilities of any African city for expatriate children in that schooling is available in English, French, German, Italian and Swedish. Medical and shopping facilities are reasonable and improving. A university exists in Addis but the Agricultural Faculty is at Alemaya, 500 km or one hour's flight away. A Veterinary Faculty is soon to be established but whether it is to be at Alemaya or Debre Zeit has not yet been decided.

"Ethiopia has by far the largest cattle population in Africa (26 million). It also has a wide range of ecological conditions, although close to Addis Ababa it is highland country, and field stations under typical Sahelian and humid tropical conditions are not available in the country. Several government research stations and ranches exist, albeit with limited staff and facilities at present, and there are several livestock development schemes just starting.

"The [Government] strongly supports the concept of the Centre and expressed its desire to have the headquarters located in Addis Ababa... An Addis Ababa location appeared to be acceptable to most donors and African countries, particularly those who prefer a location that is not strongly identified either with Anglophone or Francophone attitudes."

The Task Force had the following to say about Yaounde:

"Yaounde is a city with an adequate range of social, educational and medical facilities. Air connections are moderately good, particularly when connections via Douala are included.

"The main advantages of Yaounde are that it is the capital of a bilingual country and that the Government would warmly wel-

come the Centre. The university has an Agricultural School and, if the Centre was located in Yaounde, field station facilities would probably be available adjacent to the University Farm, about 10 km from the city.

"A wide variety of ecological conditions exist in the country — from Sahelian zone in the north to Guinean rain forest in the south, with substantial areas of highland plateaux — but the livestock population is restricted, numbering barely 2 million cattle and 4 million sheep and goats."

Signing the original World Bank/Government of Ethiopia agreement establishing ILCA, February 1973. Sitting at the table are Harold Graves, Executive Secretary of the CGIAR (left) and Dejazmatch Kassa Wolde Mariam, Minister of Agriculture, Government of Ethiopia (right). Standing, from left to right are: Derek Tribe (leader of the second Task Force), Joe Hulse (Director of the Agriculture Division of the International Development Research Centre (IDRC), Canada), Eric Gregory (IDRC consultant), Barry Nestel (IDRC; member of the Tribe Task Force, the executive secretary for setting up ILCA; subsequently chairman of ILCA Board of Trustees), Ralph Cummings, Sterling Wortman (Director of Agriculture at Rockefeller Foundation), Walter Schaeffer-Kernhardt (IBND), David Pratt (Overseas Development Administration, UK; member of the Tribe Task Force; subsequently member of ILCA Board of Trustees, then Director General of ILCA), Jean Pagot (Institut d'élevage et de médecine vétérinaires des pays tropicaux, France; first Director General of ILCA), Lowell Hardin (Ford Foundation), Ralph Hodgson (United States Department of Agriculture, USA; first chairman of ILCA Board of Trustees), Moise Mensah (Assistant Director General for Africa, Food and Agriculture Organization of the United Nations; second chairman of ILCA Board of Trustees).

In its deliberations, the CGIAR came down in favour of Addis Ababa, Ethiopia, as the favoured location for the headquarters of ILCA, and the Centre was established there in 1974.

The Government of Ethiopia provided a 10-hectare site on the outskirts of Addis Ababa for the headquarters of ILCA.

Task forces and their reports

First Task Force

Glenn H. Beck (Chairman), *Kansas State University, Manhattan, Kansas, USA*

Laurent Charette, *Laval University, Quebec, Canada*

A. Khader Diallo, *Veterinary Research Laboratory, Dakar, Senegal*

Ishmael Muriithi, *Director of Veterinary Services, Nairobi, Kenya*

Jean Pagot, *Director General, Institut d'élevage et de médecine vétérinaire des pays tropicaux (IEMVT), Maisons-Alfort, France*

David Pratt, *Land Resources Division, Overseas Development Administration, UK*

William R. Pritchard, *University of California, Davis, California, USA*

Bukar Shaib, *Permanent Secretary, Federal Ministry of Agriculture, Lagos, Nigeria*

Report: *An International African Livestock Centre: Task Force Report.* October 15, 1971. 36 pp. ILCA Library Accession Number 35311.

Construction of the headquarters complex started in 1976, and the first phase was completed in 1980 (top). The buildings were inaugurated in October 1980 by Chairman Mengistu Haile Mariam, then head of state of Ethiopia (middle). The bottom picture shows the Centre as it was in 1990, 10 years after the buildings were completed.

Second Task Force

D.E. Tribe (Team Leader), *University of Melbourne, Australia*

Barry Nestel, *International Development Research Centre, Ottawa, Canada*

David J. Pratt, *Land Resources Division, Overseas Development Administration, UK*

M. Thomé, *IEMVT, Maisons-Alfort, France*

Consultants to the Task Force

Dr K.V.L. Kesteven (Australia) – Animal health and production

Dr H.F. Lamprey (UK/Tanzania) – Wildlife research and multiple land use

Dr P. Nderito (Kenya) – Education and training in East Africa

Dr L. N'Diaye (Senegal) – Education and training in Francophone Africa

Prof. V.A. Oyenuga (Nigeria) – Education and training in Anglophone West Africa

Mr J. Tyc (France) – Economics and marketing

Report: Nestel B, Pratt D J, Thomé M and Tribe D (1973). *Animal production and research in tropical Africa.* Report of the Task Force commissioned by the African Livestock Sub-Committee of the Consultative Group on International Agricultural Research. 114 pp. ILCA Library Accession Number 00129.

Chapter 2

The early years: Focus on systems descriptions

In the early to mid 1970s, when ILCA was established, conventional wisdom had it that much of the information and technologies needed to increase livestock production in Africa were already available. The belief was that the key needs, at least initially, were the collection and dissemination of information, and research on major production systems to identify how best to use the knowledge already available from previous research. ILCA's activities in its early years clearly reflect these beliefs.

Systems research

"Systems research" was seen as a way of avoiding the "failures" of previous livestock development projects in Africa. This approach embodies studying existing production systems and the reasons why people have met the constraints of their environment in the way that they have.

Systems research involves scientists from many fields working together in interdisciplinary teams to study existing livestock production systems as a whole, identifying and testing possible innovations and defining priority areas for more intensive research. The approach used by ILCA consisted of a number of coordinated activities.

The first step was an initial problem analysis, based on a literature review and field surveys, to provide a preliminary description of the selected production systems and identify possible development paths.

This was followed by (and overlapped with):

- formulation and testing of readily acceptable improvement packages at the farm or production unit level
- continuing and progressively more intensive studies of important aspects of the existing production system
- plot or laboratory experimentation on specific components of the production system which appear to offer the best prospects for future improvement
- evaluation of production alternatives at the systems level using quantitative models.

Initial problem analysis

The first phase consists of literature studies, consultations with experienced specialists and field surveys based on interviews and direct measurements of a few baseline parameters. Production factors covered include:

- land use and access to resources, including changes over time if aerial photographs are available
- farming systems, including cropping patterns, agronomic practices and yields
- livestock dynamics, including size of livestock holdings, disease incidence and estimates of productivity and mortality based on observed herd or flock structures
- household economics, including family size and composition, subsistence needs and labour availability

Interviewing a farmer in the Ethiopian highlands. Contact with farmers was central to ILCA's systems approach to livestock research.

- economic factors, including marketing facilities and prices of inputs and outputs.

Information on these factors serves to identify the more obvious nutritional, disease and genetic constraints on livestock production, together with the relationships between animal and crop production, including such factors as the area required for subsistence crops and hence that available for growing forages. The prevailing socio-economic conditions are also identified, including a preliminary appraisal of the labour and cash available for the introduction of innovations.

Formulation and testing of improvements

Based on the initial problem analysis and a review of available technology, a sequence of likely innovations is formulated, taking into account possible land, labour and capital constraints.

An initial improvement package is then devised which can be introduced to cooperating farmers or livestock producers to evaluate the benefits of the innovations and to identify priorities for further research. The early testing of improvements by the livestock producers themselves, rather than under experimental conditions, indicates more clearly what technologies are actually feasible and how readily they are likely to be adopted.

Continuing studies in existing systems

While improvement packages are being tested, studies of the existing production systems are continued. These may involve the collection of time-series data, say on seasonal variation, or the study of one factor, such as labour availability.

Agro-ecological zones

The Beck Task Force divided Tropical Africa into three broad agro-ecological zones — arid, humid and highland — and these were taken as the basis of ILCA's initial systems research focus. The characteristics of these zones differ widely, as do their agricultural production systems and opportunities for improvements. The following definitions and assessments are those used in the report of the Beck Task Force (see Chapter 1: *Origins and mandate*).

Arid zones

The arid zones (including the wetter semi-arid zone) are characterised by rainfall that is too low or erratic to support reliable crop production: average annual rainfall is usually less than 800 mm. Towards the upper rainfall limit, however, in the semi-arid zone, cropping is increasingly important, based mainly on millet, sorghum and pulses. Although cropping and livestock production may be practised concurrently, they are more usually practised independently, by separate groups, with the animals owned by pastoralists who are more or less nomadic. This mobility permits a more efficient use of resources and allows access during the dry seasons to flood plains, irrigation schemes and farming areas when feed and water are in short supply elsewhere.

Animals in the arid zones may be forced to walk long distances and to compete for insufficient water and grazing. Birth rates are low, early mortality rates are high and sales are low.

Humid zones

The humid zones (including the drier subhumid zone) are characterised by moderate to high rainfall (usually 900 mm or more) and a natural vegetation which ranges from tree savannah in the subhumid zone to dense forest in the wetter areas. Increasingly, woodlands have been cleared by seasonal burning and, in some places, by cultivation. Large areas are infested with tsetse flies, which transmit human and animal trypanosomiasis. In these areas livestock production is limited to trypanotolerant breeds or seasonal grazing.

Seasonal grazing by cattle is an important form of land use in the subhumid zone, with herds moving into the area from the arid zones at the onset of the dry season. Annual rainfall in the subhumid zone averages 800–1200 mm, which does not support forest but is adequate for tree and grass growth and also for arable farming. Cereal production is important, as is more settled livestock production. In the humid zone proper, where annual rainfall may exceed 1500 mm, tree and root crops are more common than cereals.

Highlands

The highland environment is favourable to crop and animal production. The combination of moderate temperatures, adequate rainfall and freedom from many tropical diseases has encouraged the growth of large human populations and diverse farming systems. The main highlands zone extends from 1500 m above sea level to 3000 m, above which frost becomes a limiting factor. Although only 10% of tropical Africa lies above 1500 m, this area supports close to half the human population and about 30% of the livestock of the region.

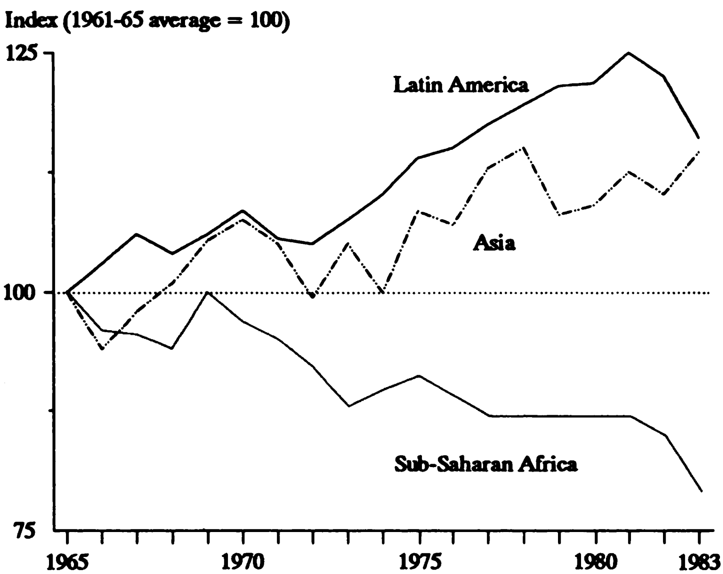
The crisis in Africa

The Consultative Group on International Agricultural Research (CGIAR) came into being in 1971. The "founding centres" of the CGIAR were based in Latin America (the International Center for Tropical Agriculture (CIAT), in Colombia, and the International Maize and Wheat Improvement Center (CIMMYT), in Mexico) and Asia (the International Rice Research Institute (IRRI) in the Philippines). Only the International Institute of Tropical Agriculture (IITA) was based in Africa. The "Green Revolution", stimulated by IRRI and CIMMYT, had resulted in large increases in food production in many parts of south Asia and Central America.

This was the backdrop to the CGIAR's deliberations in the early 1970s on the establishment of a livestock research centre. The urgency of the need to "turn around" food production in Africa was highlighted by famines in the Sahel countries in 1971–74 and in Ethiopia in 1972–74. The need for a systems approach to research to bring about Africa's own "Green Revolution," including livestock, came together in the establishment of ILCA in 1974.

The need for ILCA then was clear, as is the continuing need for agricultural research in Africa 20 years on, with Africa still the only major region of the world in which food production per person is declining.

Index of food production per person



Zonal research programmes

Early in its existence, ILCA established zonal research teams in each of these major agro-ecological zones in Africa. Studies on arid rangelands were set up in Mali, Kenya, Ethiopia and Botswana. Work on the West African subhumid zone started in Kaduna, Nigeria, and a team working on the humid zone was based in Ibadan, Nigeria. Research on the African highlands was based in Ethiopia.

Field research was started first in Mali. A Memorandum of Agreement between ILCA and the Government of Mali was signed in January 1976. This was later revised in September 1980. Work in Ethiopia in the highlands zone and in the arid rangelands also started in 1976. This was followed by programmes in Botswana (1977), Kaduna and Ibadan (1978).

The remainder of this chapter reviews some of the early research conducted in these zonal programmes.

Studies in the highlands

Since ILCA's headquarters are in Addis Ababa, the highlands of Ethiopia were a logical focus for the Centre's research. The first research programme was planned for a relatively high-potential area, combining livestock and cereal production. In 1977, the Ethiopian Government offered ILCA a 160-ha site for a research station at Debre Zeit, 50 km south of Addis Ababa. At an altitude of about 1800 m above sea level, average temperatures range from 14 to 23° C and annual rainfall averages 800 mm, with 70% falling between June and September. In 1979, the Government provided a second, 280-ha, site at Debre Birhan, 120 km north of Addis Ababa, at an altitude of about 2800 m. Here, annual rainfall varies from 900 to 1200 mm, with about 70% falling between July and September. The productivity of the cropping system at Debre Birhan is limited by poorer soils and lower temperatures, with occasional frosts. Research was conducted with cooperation from Alemaya College of Agriculture, the Ethiopian Institute of Agricultural Research and the University of Addis Ababa, which has a field station at Debre Zeit.

ILCA's early work in the Ethiopian highlands clearly displayed the Centre's commitment to systems research. Work focused on increasing the productivity of subsistence crops with improved seed and fertilisers, with the aim of releasing land for fodder production to support increased livestock production. To assess the replicability of these research programmes, crop and livestock production systems throughout the eastern African highlands were classified into zones according to ecological and land-use features and development potential.

Three main agro-ecological zones were identified in Ethiopia, as shown in Table 1. Both of ILCA's study sites are in Zone 1, which is the most important zone in economic terms.

Table 1. *Major agro-ecological zones of the Ethiopian highlands.*

	Zone 1 High potential Cereal/livestock	Zone 2 Lower potential Arid/degraded soils	Zone 3 High potential Horticulture
Area (km^2)	140 300	162 920	186 300
Population density (people/km^2)	34	32	33
Livestock density (head/km^2)	53	28	32
Climate	Humid/subhumid	Subhumid/semi-arid	Humid
Topography	Rolling plateaux	Mountains/escarpment/ low plateaux	Dissected plateaux
Main crops	Cereals, pulses livestock	Cereals, pulses livestock	Tree crops, livestock

Problem analysis: Debre Zeit

Research in the highlands began in 1976 with studies of the existing agricultural system in Ada District around Debre Zeit. Literature on the area was reviewed, but most published information had been collected before the Government implemented a major land-reform programme which substantially altered farming conditions throughout the country. In 1978, new information was collected through a series of field surveys.

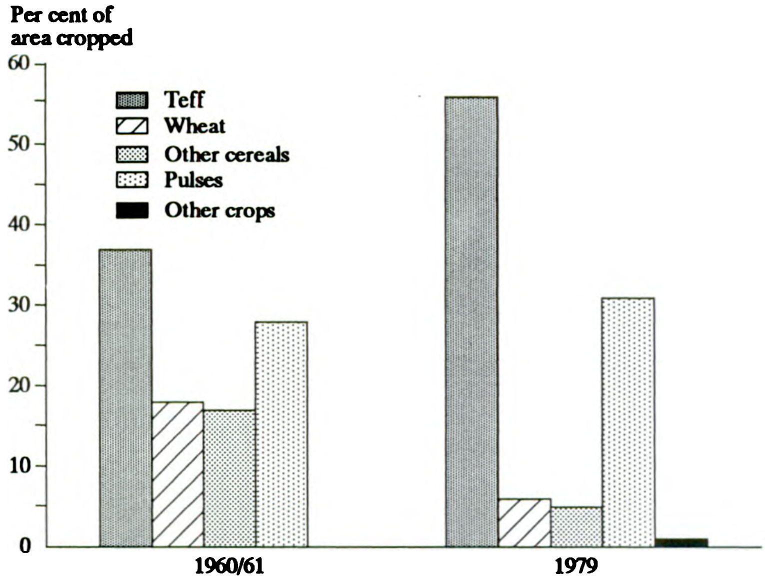
Constraint identification

This initial research identified a number of constraints to increasing livestock production. Individual landholdings were small and becoming smaller, falling from an average of 3.2 ha per household in 1960 to 2.5 ha per household in 1978. This was matched by changes in land-use patterns, with increases in the proportion of land under crops and the proportion of crop land under high-value crops such as teff (*Eragrostis tef*) (Figure 1). Fallow land had almost disappeared, falling from 18% in 1973 to only 2% in 1978.

The general scarcity of land indicated that increased livestock production based on forage crops would only be possible if the yields of the subsistence crops could be increased by enough to release land for forage production.

Surveys demonstrated the importance of livestock, particularly cattle, but also showed declines in the number of oxen and calves owned. The decline was particularly marked for oxen, with average holdings per household falling from 2.8 in 1973 to 1.4 in 1978. Cattle were the main species kept, and these were used primarily for traction. Milk and meat

Figure 1. *Cropping patterns in Ada District, Ethiopia, 1960/61 to 1979.*



production were relatively unimportant by-products of the animal production system.

The main constraints on animal production were poor nutrition combined with what was then perceived to be the low genetic potential of indigenous breeds. ILCA's baseline survey suggested that farms were producing only 60% as much feed as their livestock needed.

Shortage of labour is a common constraint in smallholder agriculture. However, ILCA's studies showed that smallholder households in the Ethiopian highlands had enough labour except in November, during the food crop harvest, and September, during weeding.

The main constraint facing smallholders in the Ethiopian highlands was lack of cash. Between 1969 and 1971, households in the Debre Zeit

A view of the Ethiopian highlands, showing the intense cropping common in this zone.

area had average cash incomes of about US$ 150 per year, 30% derived from livestock. Thus, any interventions must cost very little or be supported by loans.

Opportunities for intervention

Surveys showed a major opportunity for increased production of milk and dairy products in the highlands around Addis Ababa. In Addis Ababa demand for milk and milk products far exceeded supply, and the indications were that potential demand would be sufficient to absorb any likely increase in production from the peri-urban area. Dairying further from urban areas would be constrained by lack of transport and weaknesses in the marketing system.

Testing improved production practices at Debre Zeit

The baseline studies had demonstrated the opportunity for smallholders to produce milk and dairy products, but had also shown that feed for livestock was in short supply and land holdings were small and becoming smaller. This led to the development of a package of innovations aimed at increasing crop yields so as to release land for forage production, which in turn would support increased milk production.

In 1977, ILCA began testing a package of innovations with 20 cooperating smallholders. The main elements of the package were the use of improved seeds and fertiliser to increase teff and wheat production, the introduction of forage oats and vetch and the purchase of an in-calf Friesian x Boran crossbred heifer.

In these trials farmers using the improved package had teff and wheat yields 30% or more above those of farmers using traditional practices (Figure 2).

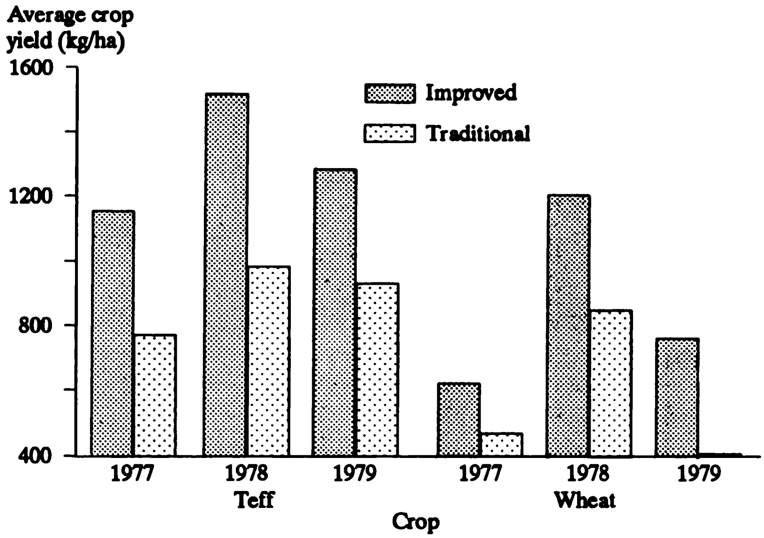
Importantly, the gross margins (value of production minus variable costs) showed a similar pattern, with those from improved practices exceeding those from traditional practices by about 30%.

The crossbred dairy cows produced an average of 2185 litres of milk in 1978 and 1805 litres in 1979, with gross margins of US$ 377 in 1978 and US$ 325 in 1979. The overall gross margin per hectare for farmers using the improved package was US$ 435.50 in 1978 and US$ 409.50 in 1979, compared with US$ 317.50 and US$ 259 for farmers using traditional practices.

Problem analysis: Debre Birhan

Farmers around Debre Birhan were first surveyed in late 1977. Regular monitoring started in 1978.

Figure 2. *Average crop yields (kg/ha) of farmers using the improved package or traditional practices.*



Constraint identification

The main constraints identified were poor soil fertility and low temperature. Much more land was fallowed than at Debre Zeit: to the south of Debre Birhan over half of the land was under natural grassland or fallow. Landholdings were larger at Debre Birhan than at Debre Zeit (3.8 vs 2.5 ha), offering opportunities to increase forage production without affecting the area planted to crops. The main crops at Debre Birhan were barley, wheat and faba beans (*Vicia faba*).

Livestock holdings were similar to those in Debre Zeit in 1978, although farmers in Debre Birhan kept more sheep and goats than did farmers in Debre Zeit. As in Debre Zeit, the main constraints on livestock production appeared to be the low genetic potential of the animals and inadequate feed production: farm feed production averaged only 65% of the animals' needs.

Innovation testing at Debre Birhan

Research farms were established on ILCA's Debre Birhan station in early 1979. These were used to investigate possibilities for increased dairying and improved sheep-fattening systems.

Complementary experimentation

Beginning in 1978, trials at Debre Zeit screened a range of annual and perennial forages for yield and nutritional quality. Fodder-screening trials at Debre Birhan, started in 1979, were aimed more at identifying species for permanent pastures, in line with the greater importance of permanent pastures in this zone.

This period also showed the beginnings of ILCA's work to improve cropping on waterlogged soils in the highlands. Early trials focused on reducing waterlogging by ditching, dyking and camberbedding. These techniques allowed waterlogged land to be cropped and high yields were obtained. However, the main constraint to using these techniques was the amount of labour involved. This led to the search for animal-powered implements that could be used to prepare land in such a way as to reduce the effects of waterlogging on crops.

Studies in the humid zone

ILCA's research in the humid zone started in 1977 with a review of literature on livestock production in the zone. This was published in 1978 as ILCA Systems Study 3, *Small ruminant production in the humid tropics.* In 1978, the Centre established its Humid Zone Programme, based at the International Institute of Tropical Agriculture (IITA), in Ibadan, Nigeria. Early collaborators included IITA, the University of Ile-Ife and the University of Ibadan.

Following on from the review of literature, ILCA's humid zone team started surveys of smallholder production systems in October 1978.

Constraint identification

These surveys described production systems dominated by tree crops and with little crop–livestock integration. Livestock, primarily goats, were kept as an adjunct to cropping and received little attention. The animals were not herded or grazed systematically but were tethered or allowed to roam freely over compounds, roads and uncultivated areas to browse and scavenge. A substantial proportion of their diet was composed of household scraps, such as cassava, plantain and yam peelings.

Deliberate production practices were limited to culling and sales. These events were, however, largely determined by cash needs and the occurrence of festivities rather than according to a strategy to maximise production. ILCA's surveys indicated that most goats were culled and sold between 6 and 12 months old. Selling animals before they are fully grown implies a serious loss of profitability, especially when keeping them longer would cost little.

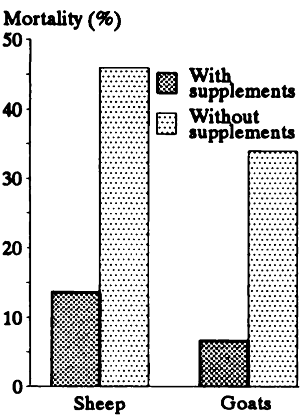
The literature review had indicated that disease and nutrition were the primary constraints on livestock production in this zone, and this was borne out by ILCA's surveys. *Peste des petits ruminants* (PPR) was shown to be a major problem, although less than earlier literature had indicated. In two outbreaks of PPR in 1979, mortality rates of 5.6 and 23.1% were recorded. Sarcoptic mange was a greater problem, accounting for 45% of all disease incidents.

West African Dwarf goats roaming free in a village in the Nigerian humid zone. Early studies showed large effects of nutrition of small ruminant productivity.

The role of nutrition was demonstrated in the surveys. Offspring of dams that were fed household scraps in addition to the normal diet from grazing, browsing and scavenging were much more likely to survive to weaning and gained more weight during their first three months (Figure 3).

The primary socio-economic constraints to increased livestock production were the small size of individual flocks, the limited supply of breeding stock on the market and shortages of cash and labour.

Figure 3. *Mortality among sheep and goats in the humid zone as influenced by supplementary feeding.*



Innovation formulation and testing

The first innovation introduced in the humid zone was a system for treating sarcoptic mange, followed by a vaccination programme against PPR. These responded to the immediate disease problems identified by the literature review and ILCA's baseline surveys.

Further interventions required a period of on-station testing before being introduced to farmers. To do this, ILCA established experimental units at Ikenne, in the forest zone, and Fashola, in the savannah zone. Land at Ikenne was provided by the University of Ile-Ife, while the Ministry of Agriculture and Natural Resources of Oyo State provided the land at Fashola.

Early trials tested three improved management systems, based on:

- improved fallow grazing with mixed flocks
- grazing on permanent planted pasture
- intensive rearing and finishing under zero-grazing.

These trials were the beginning of ILCA's involvement with alley cropping, a system developed by IITA for use with crops but subsequently modified by ILCA to integrate crop and livestock production.

Complementary experimentation

Complementary experiments focused on identifying better browses and forages to support increased animal production and on combating the disease problems found, particularly helminthiasis and PPR.

Studies in the subhumid zone

ILCA's Subhumid Zone Programme was established in the middle of 1978 at Kaduna, in northern Nigeria. The focus of the Programme was on the production system of the Fulani pastoralists, a group spread throughout the subhumid zone of West Africa. This region was already suffering shortfalls of meat and milk production and the subhumid zone showed most promise as being able to support increased crop and livestock production.

Problem analysis

As with the other programmes, the first step of the Subhumid Zone Programme was to conduct a review of literature on the zone. This was supplemented by a Symposium on the Intensification of Livestock Production in the Subhumid Tropics of West Africa, held at Kaduna in March 1979, cosponsored by ILCA and the Nigerian National Animal Production Research Institute. The proceedings of the symposium were published as ILCA Systems Study 2, *Livestock production in the subhumid zone of West Africa: A regional review.*

These reviews highlighted the importance of the subhumid zone and the changes it was facing. Primary among the changes identified were moves by pastoralists towards settling and becoming agropastoralists, and immigration from both the semi-arid zone to the north and the humid zone to the south. Research needs identified focused first on gathering information to better understand existing production systems, followed by gathering information needed to formulate strategies to improve production.

ILCA's Subhumid Zone Programme focused primarily on two case-study areas, Kurmin Biri and Abet. Aerial surveys showed that livestock

Early studies of the natural vegetation in the subhumid zone showed that the crude-protein content was adequate for most of the herd for only three months of the year.

production patterns in these areas were typical of the zone. The populations of both consisted of small clusters of farmers and settled Fulani, with transhumant Fulani coming into the region during the dry season. About 30% of the land in Kurmin Biri was or had been under cultivation, compared with about 60% in Abet. The farms of the settled Fulani were too small to meet subsistence needs, varying from about 0.1 ha to 0.5 ha.

Studies of the natural vegetation indicated that crude-protein content was adequate for most of the herd in only May, June and July. For the rest of the year, animals would need crude-protein supplements if their productivity were to be increased.

Aerial surveys in the wet and dry seasons showed large dry-season increases in the cattle populations of Kurmin Biri and Abet. This matched with the typical transhumant cycle of pastoralists spending the wet season in the arid zones and the dry season in the subhumid zone. Surprisingly, however, two other areas surveyed (Lafia and Mariga) showed influxes of cattle during the wet season (Figure 4). This finding suggested that transhumant pastoralists were remaining in the subhumid zone throughout the year, in contrast with the prevailing belief that they moved to the semi-arid zone in the wet season.

In all cases the cattle were concentrated near farmland, villages and water sources. Very few were seen in the woodlands that covered at least half of the case-study areas.

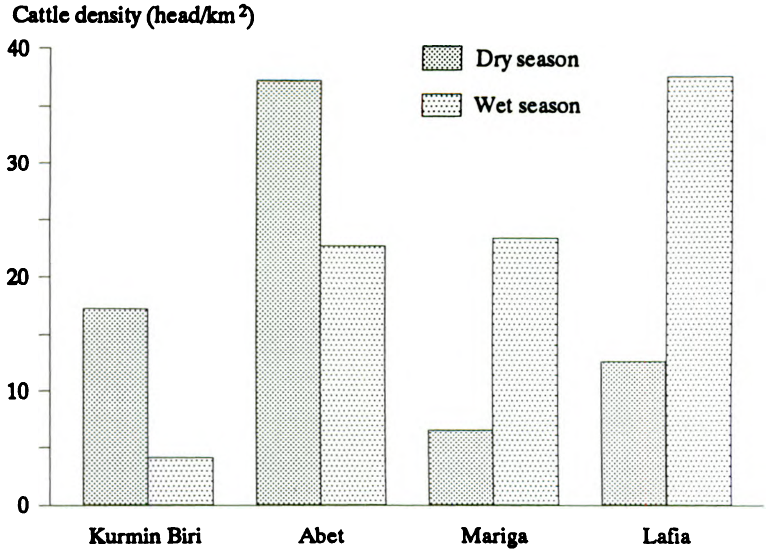


Figure 4. *Wet- and dry-season cattle populations in the sub-humid zone near Kaduna, Nigeria.*

Information collected from ILCA's baseline surveys indicated the need to improve animal nutrition, particularly increasing the amount of digestible crude protein available throughout the year. However, this had to be achieved within the constraint of little cash income and seasonal labour shortages.

Innovation formulation and testing

Initial efforts at developing systems to increase livestock production focused on improving animal nutrition through strategic feeding of fodder legumes and agro-industrial by-products. Fodder production was based on undersowing food crops with legumes, usually *Stylosanthes* species.

Difficulties were found with undersowing. The best time to sow the legume was not known, and yields of crops were reduced. Also, techniques were needed that would facilitate undersowing and management of the undersown crops. These, and improved feeding systems based on fodder legumes and agro-industrial by-products, were to be the focus of further research in 1981 and later years.

Studies in the semi-arid zone

ILCA's programme in Mali was the first of the Centre's zonal research sites. The Semi-arid Zone Programme was based at Niono and focused on livestock production systems in the Sudano-Sahelian zone.

There are four main livestock production systems in the Sahel:

- nomadic pastoralism

- transhumant pastoralism
- sedentary farming
- irrigated crop production, with animals kept mainly for traction.

All four of these systems are represented in Mali, but ILCA's research focused primarily on the transhumant and the sedendary millet/livestock production systems, with some attention to the irrigated rice production system.

Cattle on the Niger flood plain in central Mali, one of the focal areas for ILCA's semi-arid zone programme.

Problem analysis

ILCA's work in Mali provided a detailed, in-depth description of the two main livestock production systems investigated.

Forage resources were described in detail, and estimates were made of the productivity and quality of the various plant ecosystems found. These studies were matched with investigations of animal feeding strategies.

Animal nutrition

The availability and quality of forage under the transhumant system vary widely (Figures 5 and 6). Transhumant grazing strategies were complex, in response to unreliable rainfall and flooding and pressure on the best pastures. Transhumant producers rely on flood plain grazing in the Niger inundation zone for six to seven months during the dry season. Herds move onto the flood plains as the floodwaters recede in December. In June the first showers fill the ponds along the transhumant route towards Mauritania and most cattle leave the flood plain, reaching their wet-season grazing areas in late July or early August. Lack of water at

Figure 5. *Seasonal herbage availability under the transhumant production system, Mali.*

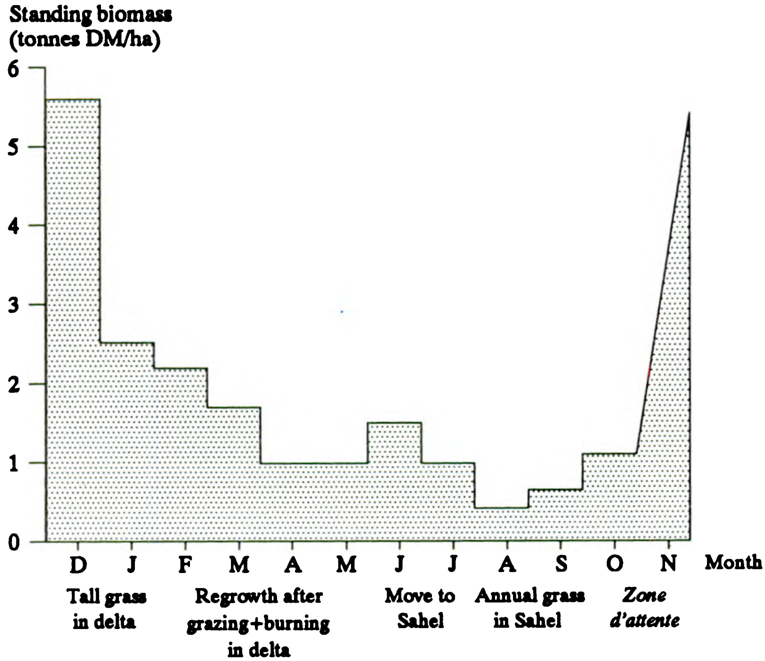
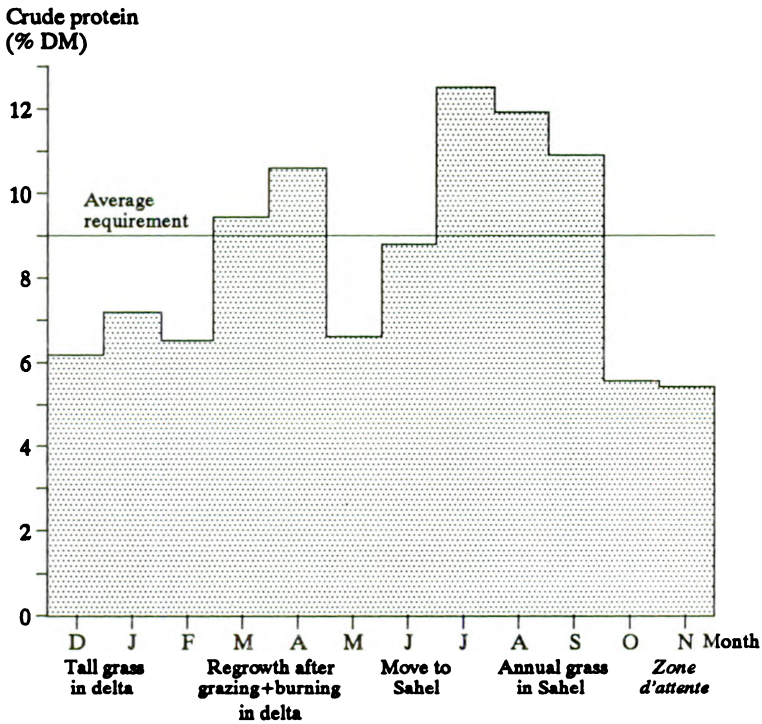


Figure 6. *Seasonal herbage quality under the transhumant production system, Mali.*



the end of the wet season forces producers to leave the wet-season grazing areas to return to the flood plain. On their return they again pass through the *"zone d'attente"*, a heavily overgrazed area offering little in the way of grazing. If the floods are late in receding herds may have to stay in this zone for an extended period, seriously reducing their productivity.

Sedentary herds graze on natural pastures and millet fallows during the wet season and on rice stubble and fallows in the dry season, with a short period of millet residue grazing after harvest in November. Grazing on millet and rice residues meet only part of the nutritional needs of the animals and grazing pressure on neighbouring natural pastures is acute.

Feed supplies in the millet/livestock system are directly related to rainfall, with three to four months of relative plenty followed by a gradual decline in availability and quality of feed (Figures 7 and 8). Feed supplies in the irrigated rice system are less linked to rainfall, and rice fallows provide good fodder well into the dry season.

These studies clearly demonstrated problems in both the amount of feed available and its quality. Crude-protein content exceeded the minimum needed for maintenance, growth and reproduction for only three months of the year in the sedentary system and five months in the transhumant system.

Figure 7. *Seasonal herbage availability under sedentary production systems, Mali.*

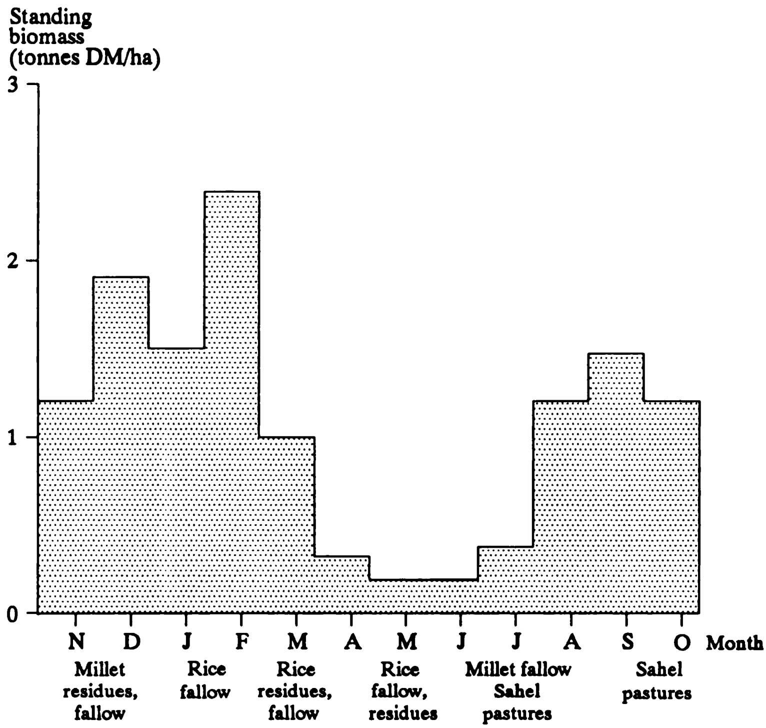
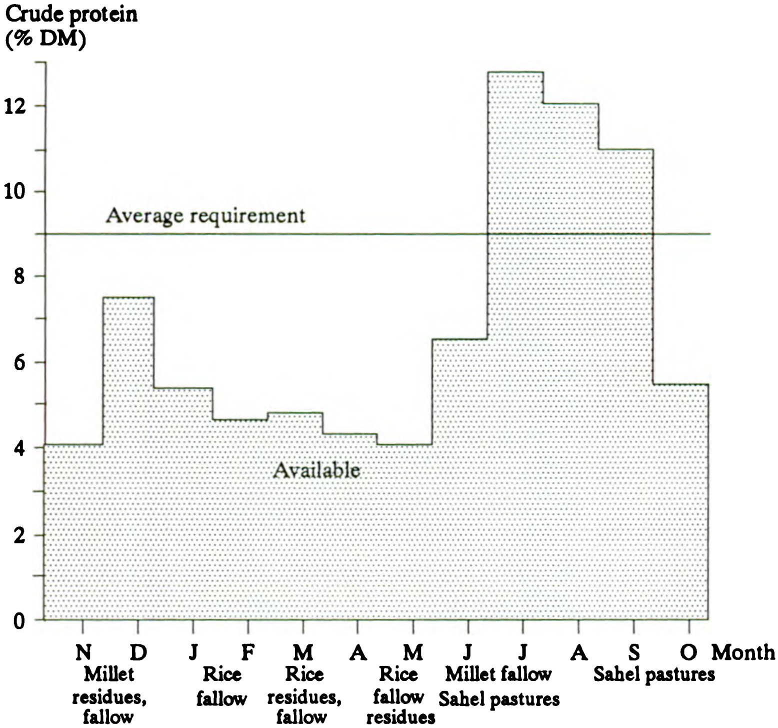


Figure 8. *Seasonal herbage quality under sedentary production systems, Mali.*



Animal productivity

Monitoring of transhumant and sedentary herds and flocks started in 1978.

In the transhumant system, only 20% of the male cattle were castrates, compared with 69% in the sedentary millet system and 70% in the sedentary rice system (Table 2).

Herd structures indicate the different uses of cattle in the different production systems. In the irrigated rice system, cattle are kept chiefly

Table 2. *Composition of transhumant and sedentary cattle herds in Mali, 1978.*

	Transhumant		Sedentary			
			Millet		Rice	
	Female	Male	Female	Male	Female	Male
0–1 year	10	10	6	6	6	7
1–3 years	17	12	11	9	11	9
3–5 years	15	4	11	6	6	5
Over 5 years	23	9	25	26	15	41
Total	65	35	53	47	38	62

to provide traction for cultivation, hence the high proportion of oxen. In this system, cattle, and particularly females, tend to be sold between two and five years old. There were too few mature females in these herds to provide replacement stock, and hence considerable numbers of oxen had to be bought in. In contrast, transhumant herds are used mainly to produce milk for subsistence and so the proportion of mature females in these herds is high.

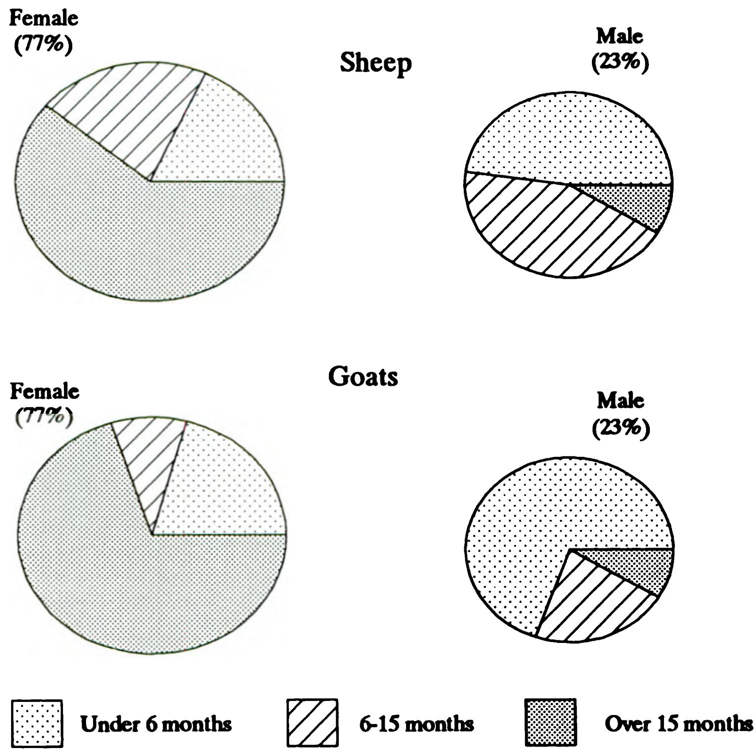
The structure of sheep and goat populations in the sedentary millet and rice systems were typical of flock compositions found throughout Africa under traditional management systems (Figure 9).

The main problems found in cattle production were poor nutrition and high mortality rates of up to 40% in calves and 12 to 13% in mature animals. The main constraint in small ruminants was the high mortality rate, with overall annual mortality rates of 50.4% in sheep and 56% in goats.

Household economics

ILCA's surveys of the transhumant systems described a system in which some livestock owners were relatively wealthy. A typical herd comprised about 50 cattle, equivalent to 35 tropical livestock units (1 TLU = 250 kg live weight), with an annual offtake of six animals weighing an average of 220 kg. About 40% of the herd was breeding females, with a

Figure 9. *Composition of sedentary sheep and goat populations in Mali, 1978.*



calving rate of 69% and an annual milk output for human consumption of 200 litres per lactating cow.

Among sedentary millet farmers in the ILCA study area, a family of four adult equivalents typically cultivated about 3.5 hectares of land, with an annual millet output per hectare of up to 600 kg of grain and one tonne of stubble dry matter. Twenty-five to 40% of households owned cattle, keeping about eight animals (six TLUs). On average, these households slaughtered one mature animal every three years, giving an average annual beef offtake of about 52 kg per household. Annual milk production for sale or consumption was about 400 litres per household. About a quarter of the households also kept sheep and goats, with flocks averaging 50 animals.

The rice farmers were all tenants of the government's Office du Niger project. A typical household comprised an extended family of about 20 people cultivating about 15 hectares of land, producing about 1500 kg of rice per hectare. Each household produced on average a further two tonnes of rice on private holdings averaging about two hectares. Over 80% of these households owned cattle, most of which were used for traction. Household herds were small; most households owned only one pair of work oxen and only 10% of households owned more than 10 animals.

Trends in land use and resource degradation

Overall, the sedentary farming population was growing more quickly than the transhumant population and livestock holdings were shifting in favour of the farming sector.

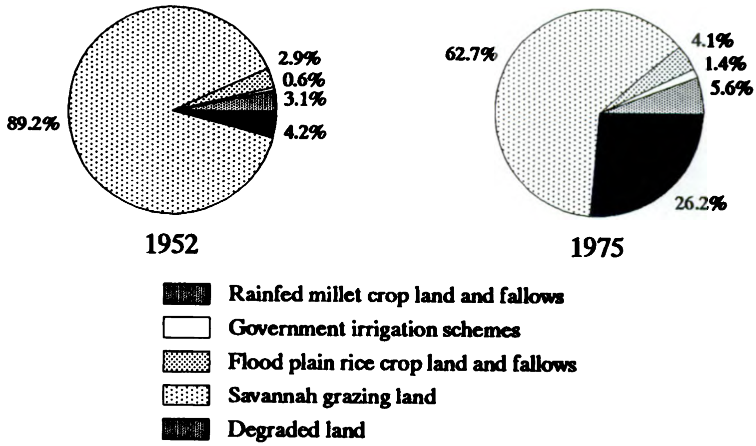
Changes in land use associated with these trends were identified by comparing aerial photographs taken in 1952 and 1975. This showed large increases in areas cropped, a reduction in savannah grazing land and a very large increase in degraded land (Figure 10).

Innovation formulation and testing

Early studies focused on grazing trials to determine range and livestock productivity and introduction trials with *Stylosanthes hamata, Lablab purpureus* and cowpea (*Vigna unguiculata*). Work was also started to determine territorial rights and land-use patterns in the transhumant system.

In 1980, the Government of Mali asked ILCA to assist in the implementation of the Office du développement d'élevage en Mopti development project in the flood plain and adjacent areas of the Sahel. ILCA's role was to identify pastoral production units that would serve as the focus of development efforts. This work started in 1981 and is reported under *"The pastoral system"* (page 59 *et seq*).

Figure 10. *Land use in the Niono area of Mali, 1952 and 1975.*



Monitoring development projects

The Tribe Task Force (see Chapter 1: *Origins and mandate*) identified the need to monitor development projects as a function of ILCA separate from the zonal research programme:

> *"It will also be important to examine the response of traditional systems to development processes. Indeed, the monitoring of ongoing development programme needs to receive a high priority, since these programmes represent unique experiments which can never be reproduced in the confines of a research station. If not given early attention, a great volume of information crucial to future livestock development will be lost. At first these studies are likely to be mainly in eastern Africa, where existing development programmes already affect a wide range of pastoral societies, though they would be selected also for their wider relevance to Africa as a whole."*

In its early years, ILCA's monitoring of development projects did indeed focus on eastern Africa, with monitoring in Ethiopia, Kenya and Botswana.

The programmes followed similar patterns, with initial efforts directed towards monitoring broad development projects covering large parts of each country, followed by focused efforts on specific production systems. A key element of the work was the development of a simple, cost-effective methodology for monitoring the progress of livestock development projects. A central monitoring team, including specialists in environmental, animal and social sciences was based in Kenya and was the focus of work on the development of the monitoring methodology. Monitoring started in Kenya and Ethiopia in 1976 and in Botswana in 1978.

Monitoring programme in Kenya

ILCA's monitoring activities in Kenya were linked to the Kenya Livestock Development Project (KLDP) and were directed towards identifying and following trends in rangeland ecology, animal productivity levels, the economic performance of participating ranches and the social organisation and production strategies of the livestock producers.

Ecological monitoring

Monitoring transects were established at 36 sites in Kenya, 16 on commercial, cooperative or company ranches, 12 on group ranches and 8 on grazing blocks. Although all the sites were in areas identified for development under the second phase of the KLDP (KLDP II), implementation was more advanced at some sites than others and development activities had not yet started at some sites.

The monitoring programme revealed a number of interesting patterns. In general, the condition of grazing areas was much more closely linked with levels of stocking and grazing strategies than with basic ecological conditions. It was discovered that maps available to ranch managers were frequently inaccurate and, partly for this reason, facilities such as tracks and watering points were not always well located. It was found that most of the ranches were understocked. However, rotational grazing schemes were frequently not put into practice, with the result that some areas were overgrazed while others were not used at all.

Herd production monitoring

Livestock production and financial monitoring activities were focused on the commercial, company and cooperative ranches covered by the KLDP. A representative sample of 11 ranches was chosen, including seven company ranches, two commercial ranches and two cooperative ranches.

The programme started with an examination of the history of each ranch, its size, the composition of its herd, its fixed and other assets and the status of the loan received from the Agricultural Finance Corporation. A system of regular record keeping was then devised, and later modified, to enable ranch managers to record all sales and purchases, veterinary treatments, births, deaths and other changes in the status of their herds. ILCA's role was to bring together and analyse the information collected, in cooperation with the government agencies involved. However, this approach was not entirely successful as the ranchers frequently failed to record the necessary data and information provided by government field workers was often inaccurate or incomplete. It was thus recognised that ILCA staff would have to collect herd productivity and ranch financial data themselves. This, in large part, led to the subsequent focus of the programme on one element of the KLDP, group ranches.

Despite the difficulties, herd production parameters were recorded and analysed for all the sample ranches. Some of the information collected is presented in Table 3. The dynamics of herd growth, calving and mortality rates and other production parameters revealed individual patterns for each ranch. Analysis of these parameters showed that livestock production was linked to the location of the ranch, the types of animals kept and climatic conditions, but above all to the level of management.

Table 3. *Live weights, birth rate and mortality rate of cattle on company, commercial and cooperative ranches under the Kenya Livestock Development Project.*

	Average live weight (kg)				
Type of ranch	Weaning	18 months	Mature cows	Birth rate (%)	Mortality rate (%)
Company	128	229	294	75	8
	105	134	265	64	17
	121	180	236	52	24
	141	247	303	69	4
Commercial	112	236	274	83	4
Cooperative	95	140	228	53	11

Economic and social monitoring

The financial situations of the different ranches varied widely: those that had financial difficulties when they were established had become so heavily indebted that their financial position was no longer viable.

During the implementation of KLDP II, a number of difficulties were encountered. For instance, the ranches were conceived primarily as beef fattening operations, based on purchasing immature stock from the pastoral areas of northern Kenya. However, during and after the 1975–76 dry period, immature animals were very expensive or were not available, and the ranches had to spend large amounts of money to buy young stock or build up their own reproductive herds. Livestock purchases as a proportion of total investments increased from 19% in 1974 to 71% in 1978 for all the ranches and stood at 86% for the group ranches.

Monitoring group ranches

In 1978, ILCA shifted the emphasis of its monitoring activities to focus on the group ranches in Kajiado Maasailand. This was accompanied by

an expansion of ILCA's social monitoring work, with efforts focused on the design of a two-tiered monitoring system. At one level, traditional anthropological field work involved the presence of a skilled observer in one area for extended periods to record in detail many aspects of community life. The second level involved the identification and monitoring of a number of observable and relatively objective attributes that could be quantified and used as indicators of a wider and more complex situation.

Interviewing Maasai pastoralists. Repeated contacts with livestock producers were central to ILCA's systems approach to research.

Training

Training was a key element of the Kenya monitoring programme. Field enumerators were trained in the methodologies for monitoring rangeland ecology and animal productivity which were developed during the first phase of ILCA's work in Kenya.

Monitoring programme in Ethiopia

ILCA's monitoring programme in Ethiopia started in 1976 when the Ethiopian Government launched a comprehensive Rangelands Development Project. This five-year project was aimed at rehabilitating and developing the most important of Ethiopia's lowland range areas. The project consisted of an integrated programme of range management, stock water development, and marketing and veterinary services in three development units, sited in the southern rangelands, the Somali rangeland area around Jijiga and the Afar rangeland area towards the north-east.

ILCA's monitoring activities were undertaken at the request of the Ethiopian Ministry of Agriculture and the Livestock and Meat Board. Work began with a baseline survey of the Jijiga Rangelands Development Unit (JIRDU), covering ecological, sociological, demographic, herd structure, economic and marketing factors and included a land-use survey and an assessment of land capabilities in the area between traditional grazing lands and expanding arable farming. This baseline study was accompanied by 18 agro-ecological, vegetation and land-use maps prepared at a scale of 1:250 000.

In early 1977, at the request of the Ethiopian Government, ILCA shifted the focus of its monitoring activities to the North East Rangelands Development Unit. Based on experience gained in the JIRDU area, a comprehensive baseline survey was carried out and the report presented to the Government in 1980. Due to security problems, the survey was limited to the southern half of the project area, covering approximately 5500 km^2. Forty-eight maps of this area were prepared, covering agro-ecological, land-use, livestock and socio-economic factors.

In each case, the monitoring techniques used were those developed by ILCA's central monitoring team in Kenya and government staff were trained in their use.

Work in the southern rangelands started in 1981 and is reported under "*Ethiopian rangelands*" (page 61 *et seq*).

Monitoring programme in Botswana

ILCA's involvement in the livestock development monitoring programme in Botswana started through an agreement with the Botswana Government in 1977. The monitoring programme focused on the First and Second Livestock Development Projects, which were closely tied to the country's Tribal Grazing Land Policy (TGLP). ILCA assisted the Government in developing its capacity to monitor the livestock aspects of the TGLP, focusing primarily on:

- the operation of the ranches developed at Nojane under the First Livestock Development Project (FLDP)
- the implementation of the Second Livestock Development Project (SLDP)
- the development of a methodology to monitor the impact of the SLDP.

Monitoring the Nojane ranches

ILCA's monitoring focused on assessing range conditions on the ranches, determining stocking rates, identifying management practices, determining livestock productivity, determining human populations supported by the ranch and investigating a range of sociological issues.

Initial monitoring showed enormous variation in stocking rate between ranches, with a range from 8 ha/TLU to 59 ha/TLU in March 1978, compared with a recommended maximum stocking rate of 10 ha/TLU. There appeared to be no grazing system — the range was simply grazed continuously by all classes of stock — and the use of the grazing area was uneven. Calving rate was very low at 30.5% a year.

Based on the data collected, a computer-based ranch simulation model was constructed which made herd projections for a period of 12 years. This projected positive cash balances from year 2 onwards and an internal rate of return on new investment of 12.5%, which was 4.5 percentage points higher than the rate of interest on the original investment loans.

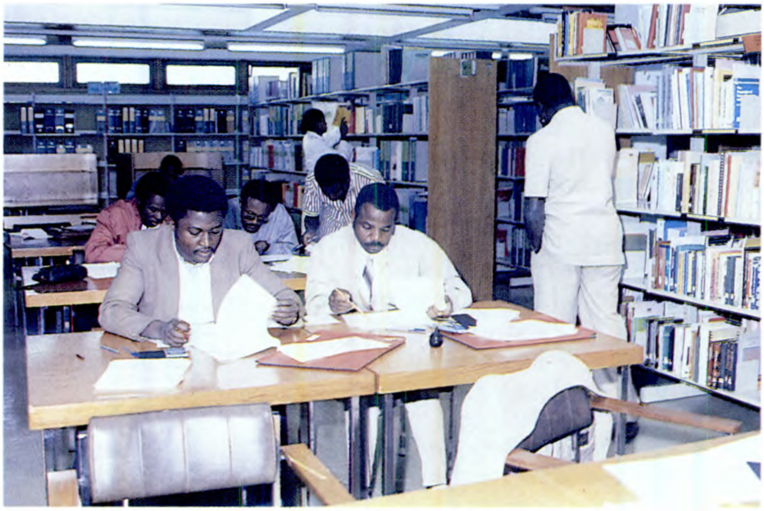
Monitoring the implementation of the SLDP

ILCA helped develop formats and guidelines for planning annual work programmes and reporting the progress of project components on a six-month basis — weaknesses found in the FLDP. Government accounting procedures were also organised to show the expenditures for each project component, as set out in the planning document. This was to:

- enable officials responsible for implementing various project components to keep in line with the budgets and schedules planned for the financial year
- keep the Government fully informed of the financial implications of the progress, or lack of progress, of the project
- provide the data base for detailed financial and economic evaluation.

Developing a methodology for impact monitoring

A methodology was devised for monitoring livestock performance and ranch economics, based on two sets of simple formats. Each rancher recorded his operations on a herd register, while extension staff used another set of formats to build up an extension file on each ranch. Besides providing feedback to the Government on the success of development efforts, the information collected was of immediate use to extension staff in clarifying the input–output situation of each ranch and its technical and financial performance.



Developing ILCA's library and information services was given high priority in the early years of the Centre, and indeed remained a vital part of the Centre's operations throughout its life.

Complementary studies

In addition to the zonal research programmes and monitoring efforts, ILCA carried out a number of complementary studies on research topics or areas of widespread relevance to livestock production systems in Africa.

Initial emphasis was placed on studies of the comparative performance of indigenous African livestock breeds. The limited genetic potential of indigenous cattle, for instance, had often been mentioned as a major constraint on beef and milk production in Africa. However, analysis of all relevant reports on cattle performance traits in Africa over the previous 30 years indicated that only 5% contained sufficient information to allow comparisons between breed types based on any meaningful indices of productivity.

Evaluation of the productivity of trypanotolerant livestock in West and central Africa

A study was initiated in 1977, in cooperation with the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme, on the use of trypanotolerant cattle, sheep and goats in West and central Africa. An index of productivity was built up which allowed the comparison of several breeds under different levels of management and trypanosomiasis challenge. The final report of the study was published in three volumes as ILCA Monograph 2, *Trypanotolerant livestock in West and central Africa*.

The report showed that trypanotolerant cattle, sheep and goats are well adapted to the ecological conditions, disease risks and local management systems found in tsetse-infested areas of West and central Africa. The productivity figures presented, and their comparison with data for other breeds in Africa, suggested, first, that the productivity of trypanotolerant livestock relative to other indigenous types is much higher than previously assumed; second, that in certain circumstances plans for increased utilisation of trypanotolerant breeds may have been immediately justified; and third, that more accurate evaluation of productivity in relation to degree of trypanosomiasis challenge could be a field of major importance. The report indicated a need for future work to focus on the collection of data on the biological and economic productivity of trypanotolerant and other breeds under a variety of trypanosomiasis challenges, management systems and other environmental influences.

This last recommendation was largely instrumental in the establishment of the African Trypanotolerant Livestock Network.

Other studies

Other breed studies included a desk study of the productivities of Maure and Peul cattle breeds based on data from the Sahelian Station at Niono, Mali; and an evaluation of the potential of Sahiwal cattle for milk and beef production, based on data collected from five herds in different environments in Kenya. These were published as ILCA Monograph 1, *Evaluation of the productivities of Maure and Peul cattle breeds at the Sahelian Station, Niono, Mali*, and ILCA Monograph 3, *Sahiwal cattle: An evaluation of their potential contribution to milk and beef production in Africa.*

In addition to these, a bibliographic review of the camel in Africa was conducted and published as ILCA Monograph 5, *The camel* (Camelus dromedarius): *A bibliographical review*, and a series of studies were initiated on water resources and their exploitation. These were subsequently published as ILCA Research Report 6, *The water resource in tropical Africa and its exploitation*, ILCA Research Report 7, *Livestock water needs in pastoral Africa in relation to climate and forage*, and ILCA Research Report 8, *Organisation and management of water supplies in tropical Africa.*

Training and information

Documentation

One of ILCA's first major activities was in the field of documentation. In March 1974, at ILCA's initiative, a meeting was held at FAO headquarters in Rome, Italy, that brought together representatives of the main documentation centres in the field of tropical animal production. This meeting enabled ILCA to start designing an information network that would avoid duplicating the work of other centres and ensure best possible use of the materials already gathered and classified.

Following the meeting, ILCA organised its storage and retrieval system along two main lines: compatibility with the then-new FAO international systems, AGRIS and CARIS, to facilitate exchange of information, and suitability for eventual automation. Work was started on preparing a vocabulary of livestock terms compatible with the AGRIS codified language, and in January 1975 ILCA agreed to take on the role of specialist centre on livestock in the Agricultural Libraries Network, AGLINET.

Only about half of the literature on animal agriculture is published in primary journals and subsequently covered by abstracting services. Much of the literature, especially in developing countries, is produced as non-conventional documents. In 1978, ILCA documentalists started to collect such materials systematically. A team consisting of a documentalist and a microfiche unit travelled widely in Africa, visiting research institutions, government ministries and documentation centres. These collecting missions were financed by a grant from the International Development Research Centre (IDRC), Canada. By 1981 microfiching missions had been conducted in Burundi, Ghana, Nigeria, Senegal, Sudan, Tanzania and Zimbabwe.

In 1980, a Hewlett Packard 3000/III computer was installed at ILCA's headquarters. This, combined with the MINISIS bibliographic database program developed by IDRC, formed the basis of a widening range of information services provided by ILCA over much of the rest of the life of the Centre. By 1981 the database already held the abstracts of about 12 000 documents, mainly non-conventional literature.

Training

The training programme of ILCA concentrated on strengthening the research capacities of national programmes in sub-Saharan Africa. In its first years, the Centre responded to the need to enable African graduate students to undertake their degree-related research in Africa, on constraints to improved livestock production in the continent. ILCA's graduate associate programme started in 1978 with students from Kenya, Mali and Nigeria working with ILCA research programmes in their home countries. By 1982, 19 people had received individual training from ILCA.

ILCA's first group training course held in Addis Ababa was a bilingual (English/French) course on livestock systems research, held in 1981. That year saw the completion of ILCA's conference and training facilities at its headquarters and marked the beginning of ILCA's group-training activities.

However, ILCA had been involved in a number of training courses prior to 1981. The first course the Centre was involved in was a course on animal nutrition in tropical and subtropical regions, cosponsored by the University of Hohenheim's Institute for Animal Nutrition and held in Hohenheim in February 1978. Also in 1978, a seven-week course on livestock development projects was held in Nairobi, Kenya, cosponsored by ILCA and the Economic Development Institute of the World Bank. Course tutors included staff of ILCA and the World Bank and specialists from the University of Nairobi, the Kenya Ministry of Agriculture and several livestock and rangeland development projects in eastern Africa.

Conferences

The early years also saw ILCA involved in a number of conferences and workshops. These included:

- A Seminar on the Evaluation and Mapping of Tropical African Rangelands, held in Bamako, Mali, in March 1975, the proceedings of which were published by ILCA (*Evaluation and mapping of tropical African rangelands*).
- A short workshop on data collection and analysis methodologies in animal production research held in Addis Ababa in January 1977.
- A symposium on the optimisation of agricultural production systems in arid areas held at the Centre de recherches zootechniques at Sotuba, near Bamako, Mali, in 1977, and cosponsored by ILCA, the Club du Sahel and the Comité permanent inter-Etats de lutte contre la secheresse dans le Sahel.
- A Workshop on East African Pastoralism in Nairobi, Kenya, in August 1977, the proceedings of which were published as *East African pastoralism: Anthropological perspectives and development needs* (S.B. Westley, ed.).
- A Workshop on Range Livestock Development Curricula, held in Nairobi, Kenya, in September 1978, cosponsored by ILCA and the University of Nairobi. A similar meeting was held in Dakar, Senegal, in January 1979, cosponsored by ILCA and the Ecole inter-Etats des sciences et médecine vétérinaires.
- A Symposium on the Intensification of Livestock Production in the Subhumid Tropics of West Africa held at Kaduna, Nigeria, in March 1979, cosponsored by ILCA and the Nigerian National Animal Production Research Institute. A report from the meeting was published as ILCA Systems Study 2, *Livestock production in the subhumid zone of West Africa: A regional review.*
- A workshop on aerial survey methods held in Nairobi, Kenya, in November 1979, cosponsored by ILCA, the United Nations Environment Programme and the Kenya Wildlife Conservation and Manage-

ment Department. A report from the meeting was published as ILCA Monograph 4, *Low level aerial survey techniques.*

- A Workshop on the Design and Implementation of Pastoral Development Projects for Tropical Africa held in Addis Ababa, Ethiopia, in February 1980. A summary of the workshop proceedings was published as the first issue of the *ILCA Bulletin.*
- An International Symposium on Browse in Africa held at ILCA headquarters in April 1980, the proceedings of which were published by ILCA as H N Le Houerou (ed), *Browse in Africa: The current state of knowledge.*
- A Workshop on Smallholder Dairy Development in the East African Highlands, held at ILCA headquarters in August 1980.
- A workshop on Impact of Animal Disease Research and Control on Livestock Production in Africa, held in Nairobi, Kenya, in September 1980 and cosponsored by the Organization of African Unity's Inter-African Bureau for Animal Resources, the German Foundation for International Development and ILCA.
- An International Workshop on *Peste des petits ruminants*, held in Ibadan, Nigeria, in September 1980.
- The ILCA/Association for the Advancement of Agricultural Sciences in Africa Workshop on Utilisation of Agricultural, Forestry and Fisheries Waste Products, held in Douala, Cameroon, in November 1980.
- A Workshop on the Utilisation of Agro-industrial Byproducts and Crop Residues in Animal Feeding, held in Dakar, Senegal, in September 1981 and cosponsored by ILCA and FAO.

First Quinquennial Review of ILCA

ILCA underwent its first Quinquennial Review (QQR) in later 1981. Key among the recommendations of the QQR team was that ILCA should increase its emphasis on component research to build on the knowledge gained from the largely descriptive systems studies carried out up till then. ILCA's response to this recommendation is reflected in Chapter 3: *Systems description and component research: ILCA's programme matures.*

Chapter 3

Systems description and component research: ILCA's programme matures

If the first phase of ILCA can be considered the "systems description" phase, the period leading to the second quinquennial review (QQR) of the Centre can be considered as being characterised by a mix of continuing system description and component research to overcome constraints identified during the first phase. This change was partly in response to the recommendations of the first QQR of ILCA in 1981 and partly reflected the natural evolution of the Centre's programmes.

The main organisational structures in the Department of Research continued to be the zonal research teams, although towards the end of this period a number of disciplinary research divisions and units were established at the Centre's headquarters.

Highlands

By 1981, ILCA's Highlands Programme completed its initial descriptions of the highlands production systems around Debre Zeit and Debre Birhan, and the results were published as an ILCA Research Report in 1983 (ILCA Research Report 4, *Research on farm and livestock productivity in the central Ethiopian highlands*). While studies of the systems continued with the objective of refining the definition of the farming systems, emphasis changed to component research on constraints and opportunities that had been identified in the first phase of system description.

Key among the constraints that had been found were shortage of feed for livestock, waterlogging during the rainy season and shortage of traction animals within individual households. Opportunities included dairying, improvements to the use of traction animals and better utilisation of feed available.

Importance of Vertisols

The system study showed that nearly a quarter of the land cropped in the Ethiopian highlands was on Vertisols — deep cracking clay soils prone to waterlogging. While already important, only a quarter of the Vertisols in the highlands were cropped, the remainder lying fallow because of lack of drainage. The importance of these soils was further underscored by the finding that they accounted for about 70% of all Ethiopian highland land with slopes of less than 8%.

Some Vertisol areas were found to be planted to crops tolerant of waterlogging, such as teff (*Eragrostis tef*), while others were planted only late in the rainy season with less water-tolerant crops such as chickpea. The latter practice drastically shortens the potential growing season and reduces the amount of water available to the crop. Thus, the high productive potential of the Vertisols is not fully exploited.

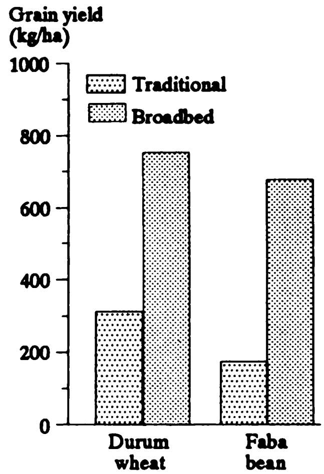
Early trials showed that large increases in crop production could be achieved through improving surface drainage on Vertisols. On-farm trials in 1985, for example, showed that surface drainage increased wheat grain and straw yields by 89 and 52%, respectively, and even increased teff grain and straw yields by 26 and 24%, respectively, despite the water-tolerant nature of this crop. In 1986, grain yield increases of 25 to 63% for bread wheat, 144% for durum wheat, 297% for faba beans (*Vicia faba*) and 84% for finger millet were recorded on farmers' fields.

A collaborative project was started in 1986 to study ways to increase the contribution of Vertisols to food and feed production in the Ethiopian highlands. The project involved ILCA, the International Crops Research Institute for the Semi Arid Tropics (ICRISAT), based in India, and the

The benefits of planting crops on raised beds is obvious here — the faba beans on the right are growing on broadbeds, those on the left are growing on the traditional flat seedbed.

Institute of Agricultural Research, Ministry of Agriculture, Alemaya University of Agriculture and the Addis Ababa University in Ethiopia, and built on earlier work by ILCA in the Ethiopian highlands. Funding for the project came from the Swiss, Norwegian and Finnish governments, Caritas Switzerland and Oxfam America. ICRISAT had for several years been experimenting with a wheeled tool bar that could be used to form broadbeds and furrows — raised beds with shallow drainage ditches between them — to improve surface drainage on Vertisols in India. Early studies by the Joint Vertisol Project showed that, while this implement was effective, it was far too expensive for smallholder farmers in the Ethiopian highlands. The project thus set out to develop a broadbed maker that would achieve the same results but that would be based on local skills and materials. This implement, the broadbed maker or BBM, was tested in its first version in 1986 at four sites ranging in altitude from 1900 to 2600 metres above sea level.

Figure 11. *Grain yields of wheat and faba bean grown on traditional flat plots and broadbeds and furrows, Were Ilu, Wello, Ethiopia, 1986.*



Broadbeds and furrows and labour requirements

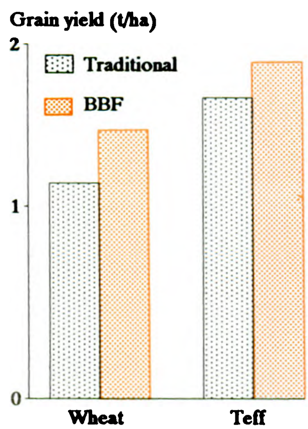
One of the sites where the BBM was tested was the Inewari Vertisol plateau in central Ethiopia at 2600 m above sea level. Farmers in this area traditionally made broadbeds and furrows (BBFs) by hand. Early trials with using the BBM showed that it halved the amount of labour needed to make the beds and furrows (30 vs 60 hours/hectare) and reduced the total labour requirement for land preparation, seeding and drainage for wheat from 120 hours per hectare in the traditional system to 90 hours per hectare with the BBM. This, combined with a 63% increase in wheat grain yield on the BBM-made broadbeds, increased return to labour by 140% (US$ 0.60/hour vs US$ 0.25/hour).

BBFs and crop yields

On the Were Ilu Vertisol plateau, also at 2600 m above sea level, farmers do not traditionally use broadbeds and furrows and hence surface drainage is poor. Crop yields are generally low in high-rainfall years. The 1986 crop season was very wet — 31 rainy days were recorded in August — and the resultant heavy waterlogging depressed yields throughout the plateau. Yields on the BBFs were, however, comparable to those achieved in good years (Figure 11).

Trials in 1986 also demonstrated that the benefits of BBFs were not restricted to high-rainfall years. At Debre Zeit, at 1900 m above sea level, teff and wheat yielded more grain on BBFs than on traditional flat plots even though rainfall was one third below average (Figure 12).

Figure 12. *Grain yields of wheat and teff grown on traditional flat plots and broadbeds and furrows on 34 farms in Debre Zeit, Ethiopia, 1986.*



Increasing milk production

An early improvement tested by ILCA was that of small-scale dairying. The package comprised a crossbred Boran x Friesian cow fed on oats/vetch forage and the use of fertiliser and improved seed for cereal

In the early 1980s, ILCA tested a range of animal-drawn implements that could be used to increase the overall productivity of draft oxen in the highlands. These included an ox-drawn scoop (top), a terracing plough (below) and a plough that could be pulled by a single ox rather than the usual pair of oxen.

In 1983, ILCA demonstrated that the oxen owned by a group of 50 farm families should be able to excavate a 6000-m3 pond during a single dry season. The technology was taken up and disseminated by the Ethiopian Ministry of Agriculture, and by 1987 some 3000 scoops had been made and distributed throughout the country.

In 1986, the Ministry announced a country-wide trials programme designed to introduce technology developed by ILCA and the Ethiopian Institute of Agricultural Research. Trials included the broadbed maker, a row planter, the ox-drawn scoops, alley cropping with Sesbania, *introduction of forage legumes and use of rock phosphate fertiliser.*

cropping. Crop yields increased, allowing farmers to reduce their food crop area, thus releasing land for growing forage. This package was first introduced to 18 farmers in Debre Zeit in 1978. Up to 1982, this package quadrupled farm income from US$ 200 per year to US$ 800 per year. On-farm studies indicated average annual milk yields of about 2000 litres from crossbred dairy cows, about six times the yield from indigenous cows. As a result, the dairy enterprise increased the cash incomes of the farmers to two to four times that of traditional farmers in the same areas who did not have the dairy enterprise (see also Chapter 4, *"Calf rearing"* (page 103 *et seq*)).

Problems encountered with the package included difficulties of producing enough feed for the cows and access to markets for milk. Farmers in the Debre Zeit area generally had relatively good access to markets, but this would not be the case for most farmers in highland

Famine in Ethiopia: The ox/seed project

In the early 1980s, ILCA was experimenting with modifications to the traditional Ethiopian plough and its yoke to allow the implement to be pulled by a single ox rather than the usual pair of oxen. By 1983 ILCA was monitoring 40 test farmers using the single-ox plough and more than 140 farmers had approached ILCA for assistance in using the system. The following year, however, found Ethiopia facing a severe drought and large numbers of hungry people left the land as their food supplies ran out. ILCA's staff and their friends raised over $250 000 to support famine relief efforts. Then in 1985, with large donations from several charities and an aid agency, the ox-seed project was launched. This aimed at helping farmers stay on the land and become self-supporting again.

Major donors to the project during its first year were Oxfam America, Oxfam UK, Medios (Belgium), Comité Français contre la Faim and the Gesellschaft für Technische Zusammenarbeit (Germany). Additional donors for the second year included Caritas Catholica (Belgium) and the Royal Shakespeare Company (UK).

Oxen were bought, taken to a holding area and maintained during the crucial months before the main ploughing and cropping season. In the first year, 600 near-destitute farmers were each provided with an ox, a single-ox yoke and harness and enough food and seed grain to enable them to work and plant a crop. Local blacksmiths made the yokes and harnesses, while ILCA staff trained the farmers to use the single-ox plough.

Fields were mostly stony and steeply sloping. The land was badly degraded and extensively eroded. Initial cultivation was usually done using pairs of oxen, farmers pairing up to share their oxen. This was in part because the soil was too hard to plough with the single ox, but also in large part because the farmers were sceptical about using the new system. The single-ox plough was mainly used for the last cultivation and for seed covering. However, even this meant that farmers using the single-ox plough were able to plant on time, whereas those who continued to use pairs of oxen often planted late because of having to share oxen.

Earlier planting over larger areas, combined with the use of an improved sorghum variety meant that project farmers had crop yields double those of their neighbours who were not covered by the project.

In 1986 another 1200 farmers were provided with the ox/seed package and monitoring was continued.

The project demonstrated the benefits that could be had from the single-ox plough, and the importance of livestock in post-drought recovery.

regions. This led to studies directed at improving milk processing to preserve surpluses of milk in valuable and marketable forms.

A study of milk processing techniques showed the main dairy products made in the Ethiopian highlands to be soured milk, butter and a form of cottage cheese. Butter is always made from sour milk, not cream, and is churned in a clay pot or a bottle gourd. The cottage cheese is made from the butter milk remaining after the butter is skimmed off. The study showed that the churning techniques used in traditional butter making are inefficient, leaving much of the butterfat in the buttermilk.

As a means of increasing the efficiency of butter making, the Programme developed a simple, cheap paddle that could be fitted inside the traditional churn to increase churning efficiency. Trials showed that 90% of the fat in the soured milk could be recovered using the paddle agitator, compared with less than 70% of fat recovered by many traditional producers. The agitator also cut churning times from more than two hours to less than one hour, thus reducing women's workloads. Tests on alternative processing systems and products, including a range of cheeses and improved soured milks were started.

Research on milk processing carried out after 1987 is reported in Chapter 4 under *"Milk preservation and processing"* (pages 105–106).

Increasing feed production

Low soil fertility limits crop and pasture production throughout the African highlands, yet few farmers are able to afford chemical fertilisers. An alternative source of nitrogen is legumes, which, through their symbiosis with *Rhizobium* bacteria, fix nitrogen from the atmosphere, making it available to themselves and following crops. Legumes are also a source of high-quality feed for livestock, and including them in the cropping system would increase both the amount and quality of feed available to livestock.

ILCA's research on legumes focused on:

- identifying high-yielding legumes with good N-fixation rates and with tolerance to low soil fertility and
- designing systems in which legumes could be integrated effectively into food crop production systems.

This work identified a number of promising clovers, including *Trifolium tembense, T. rueppellianum* and *T. steudneri*, which grew well even on poor soils. However, trials also demonstrated dramatic increases in yield with phosphorus fertilisation (Figure 13). Further trials with these legumes were conducted by the Forage Network in Ethiopia (FNE) and the Pastures Network for Eastern and Southern Africa (PANESA).

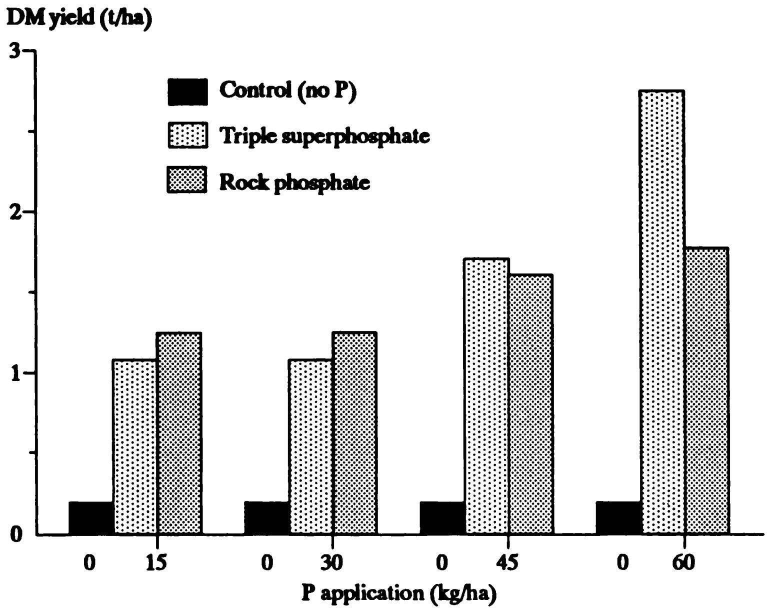


Figure 13. *Relative effects of triple superphosphate and rock phosphate on* Trifolium steudneri, *ILCA headquarters, 1984.*

Humid zone

Initial studies by ILCA in the humid zone of West Africa showed that small ruminants were kept by the majority of households in the zone but that they received little management attention. Key constraints on their productivity were disease, especially *peste des petits ruminants* (PPR), and insufficient feed to support a larger population of small ruminants. The International Institute of Tropical Agriculture (IITA), where ILCA's Humid Zone Programme was based, had developed alley cropping in response to concerns about shifting cultivation and shortening fallow periods in the crop production system. Alley cropping consisted of planting food crops between hedgerows of leguminous trees and using the foliage from the trees to mulch the "alleys." Early interventions tested by ILCA built on this production system, diverting foliage from its use as mulch in the IITA system to use it as feed for small ruminants.

Disease control

In 1982 the Programme started a long-term evaluation of a health package for small ruminants in five villages near Fashola, Oyo State. The package consisted of annual vaccination against PPR with tissue culture rinderpest vaccine (TCRV) and monthly dipping against sarcoptic mange using an acaricide.

Over 27 months, from May 1982 to July 1984, this package halved mortality among village goats. In villages where animals were treated goat populations more than doubled in 24 months (rising from 114 in May 1982 to 248 in May 1984) and populations were continuing to rise. Goat populations in villages where the package was not applied

Pruning the hedgerows in an alleyfarm. ILCA research examined the use of the prunings as livestock feed rather than as mulch.

fluctuated considerably but never increased by more than 35% over the initial populations. These results indicated that flock size was primarily limited by PPR. While there was no apparent nutritional constraint at the time, the ILCA programme decided to focus its research on increasing feed production, since rapidly rising goat populations would be likely to cause feed shortages in the near future.

Browse production and use

ILCA's work on browse production and use in the humid zone started in 1981 with initial studies of the effects of including sheep and goats in the alley cropping system pioneered by IITA. Early screening trials of a range of browse species showed that *Leucaena leucocephala* and *Gliricidia sepium* — the two species already being used by IITA — were the most productive and manageable species in the alley-cropping system and subsequent research focused on these two species.

Work on alley farming carried out after 1987 is reported in Chapter 4 under *"Forage production and feeding systems"* (pages 121–122).

Feeding value of *Gliricidia* and *Leucaena*

Trials in 1982 showed that sheep and goats maintained good condition when fed a ration consisting of two-thirds *Gliricidia* foliage over four months during the dry season. However, sheep fed a diet containing more than 60% *Leucaena* foliage showed signs of mimosine toxicity within six weeks. Goats showed no signs of toxicity, but needed up to 10 weeks to adapt to high-*Leucaena* diets.

Long-term studies on the effect of browse supplementation on animal productivity started in 1983. In these trials sheep and goats were fed a basal diet of chopped *Panicum maximum ad libitum* supplemented with a mixture of *Gliricidia* and *Leucaena* browse at a rate of 135 g dry matter per adult animal daily. This level of supplementation was based on an alley-farming model in which approximately 75% of all tree foliage was returned to the soil as mulch while the remaining 25% supplied a daily browse supplement for up to 15 adult animals per hectare.

Lamb survival and growth rates increased with the level of supplementation (Figure 14). Ewes consuming 371 g of mixed browse dry matter daily produced lambs that grew almost twice as fast as those from unsupplemented ewes.

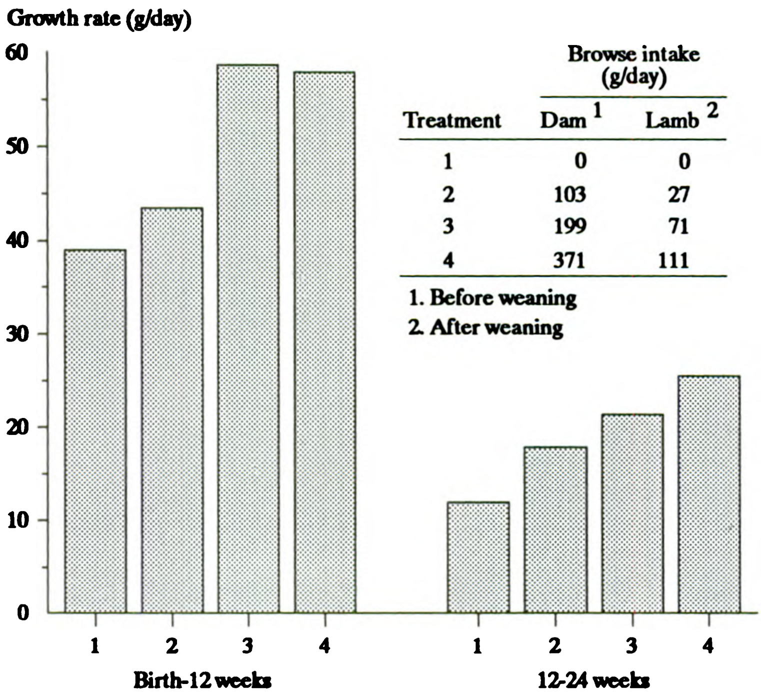


Figure 14. *Effects of browse supplementation on the growth rate of West African Dwarf lambs.*

Forage agronomy

ILCA's research demonstrated the ability of *Gliricidia* and *Leucaena* to produce large amounts of foliage, with yields of 6 to 6.5 t dry matter per hectare being common. Using this material as mulch provided the equivalent of over 200 kg N/ha to crops grown in the alleys.

Introducing a two-year grazed fallow into the crop rotation on alley farms was shown to increase maize yields compared with continuous

Table 4. *Effect of a two-year grazed fallow on maize grain yield in an alley-farming system in southern Nigeria.*

	Grain yield (t/ha)			
	1983	1984	1985	
Treatment	First season	First season	First season	Second season
Continuous cropping (no trees)	1.86	2.17	2.13	0.93
Continuous alley cropping	2.17	3.06	2.41	1.70
Alley cropping after fallow	-	-	3.30	2.05

cropping in alleys and continuous cropping without trees (Table 4). Tree foliage production was higher after the fallow period, possibly due to increased root development while pruning was less frequent. Soils under alley farming and grazing systems were richer in organic carbon and major nutrients such as nitrogen, calcium and magnesium. The nitrogen content of maize leaves was highest in alleys after the fallow; thus fallowing would increase the feed quality of crop residues.

In 1983 a pilot project on integrating small ruminant production with alley cropping started in south-west Nigeria, in conjunction with the National Livestock Projects Unit. The pilot project involved control of PPR using TCRV and the establishment and management of leguminous trees to maintain soil fertility and to provide feed for sheep and goats. In the first planting season (1984), 68 farmers established alley farms. In 1985 another 46 farmers approached the resident extension worker for seed and advice and successfully established alley farms (Figure 15). In this way, alley farming spread to three neighbouring communities.

The flexibility of the system and the freedom of action allowed to farmers in the establishment and management of the farms were believed to be important factors in the manifest acceptability of alley farming. The alley farms established displayed wide variations in terms of crops planted, level of management and the way in which the trees were used. In 1985, almost half the farmers used the foliage for both feed and mulch, while half used it for mulch only. Only one farmer used the foliage entirely for animal feed.

Subhumid zone

The initial system study in the subhumid zone in northern Nigeria clearly showed that the primary constraint on livestock productivity in the zone was the inadequacy of the amount and quality of feed available during the dry season.

Initial studies investigated ways of incorporating forage legumes into the cropping system, particularly with sorghum. The date of undersowing was found to be critical. If planted with the crop the legume

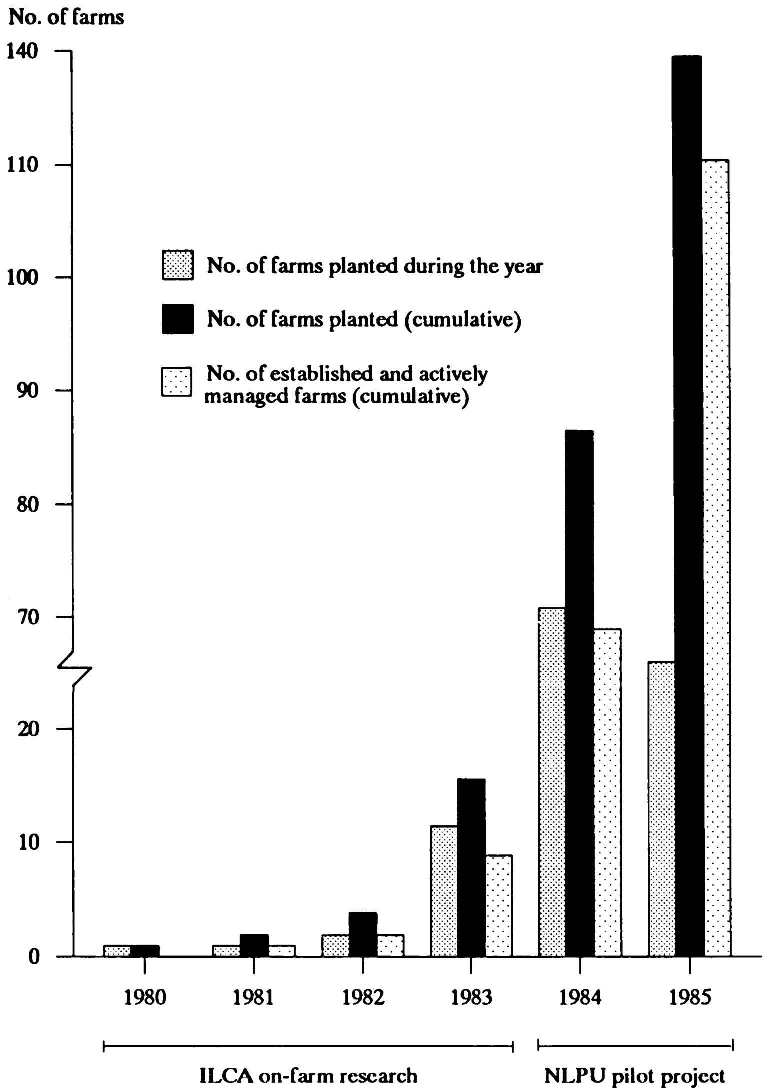


Figure 15. *Number of alley farms established in south-west Nigeria between 1980 and 1985.*

Stylosanthes guianensis gave high yields of fodder but drastically reduced sorghum grain yield. Delaying planting the legume by three to six weeks gave good yields of *Stylosanthes* with little reduction of sorghum grain yield. Unfortunately, it was believed that shortage of labour during the cropping season would preclude the adoption of this practice, and the Programme's research subsequently focused on producing forage on fallowed land.

Fodder banks

An alternative to growing forage legumes with crops was planting them on fallowed land. But again, this faced the constraint of shortage of labour. ILCA's Subhumid Zone Programme found an innovative way round this — using the animals themselves to "cultivate" that land. Animals were first corralled on the land to be planted with legumes. This helped break up the soil surface, while their manure and urine enriched the soil. Seed of the forage legume *Stylosanthes guianensis* or *S. hamata* were then broadcast and trampled into the soil by the cattle. The animals were then allowed to graze off pioneer grasses which would otherwise compete with the legume seedlings. In this way, a "fodder bank" or dense, leguminous pasture could be easily and cheaply established. These pastures were fenced off and grazed during the dry season.

Early studies showed that a four-hectare fodder bank was sufficient to provide the protein equivalent of 1 kg of cottonseed cake per day over the dry season for 10 cows in the last month of pregnancy and the first four to six months of lactation.

Five fodder banks were established in 1981 and another 16 were established in 1982. Yields of up to seven tonnes of dry matter were achieved at the end of the growing season, two-thirds of it from *Stylosanthes*, with an average crude-protein content of up to 14%.

A utilisation trial was carried out on fodder banks in the 1983/84 dry season. A control group of 14 animals grazed natural pastures while two other groups grazed fodder banks, one for two hours a day and the other for four hours a day. The control group of cattle lost 56 kg, or 23.5% of initial body weight, over the 87-day trial period between January and April 1984. The group grazing fodder banks for four hours a day lost only 26 kg, while the group grazing fodder banks for two hours a day lost 31 kg. During the course of the experiment, six cows and two calves in the control group had to be culled, whereas all the animals grazing fodder banks survived the dry season. These results were achieved despite low yields of the fodder banks (2.5 t/ha at the beginning of the grazing period) caused by an unusually short growing season.

White Fulani cattle corralled on land to be planted with Stylosanthes *to form a fodder bank. The animals help break up the surface, while their manure and urine enrich the soil.*

Analysis of six years' data showed that feed supplementation during the dry season increased overall cow productivity by over 34% (Table 5). Supplementation reduced cow and calf mortalities and calving interval and increased milk yield and calf growth. Other results showed that herds with access to fodder banks could maintain their size from births alone, whereas those without access to fodder banks would decline in size.

Table 5. *Effect of dry-season cow supplementation on the productivity estimates of Bunaji (White Fulani) cattle under traditional management.*

	Non-supplemented	Supplemented
Cow survival (%)	94.0	100.0
Calving percentage	48.7	51.5
Calf survival (%)	71.8	86.3
Calf weight at one year (kg)	98.1	103.4
Lactation milked-out yield (kg)	300.2	312.5
Productivity index (kg/cow per year)[1]	47.5	63.8

1. Total weight of one-year-old calf plus liveweight equivalent of milk produced.

Fodder-bank management

Early results showed that nitrophilous grasses could come to dominate the herbage of fodder banks within three years of the *Stylosanthes* being planted. Research showed that the grasses could be controlled through careful grazing management, but studies of producer-managed fodder banks showed that this was rarely achieved, fodder banks being either over- or undergrazed.

An alternative way of reducing the invasion of grasses was to reduce the build up of nitrogen under the legume pasture through periodic cropping. This would serve to encourage crop farmers to set aside land for fodder banks even if they themselves did not keep livestock.

Trials started in 1984 showed that maize grown within a fodder bank yielded 1.5 to 2.5 tonnes more grain per hectare than maize grown on adjacent continuously cropped land. These yield increases were equivalent to the effect of applying 90 to 110 kg of nitrogen per hectare. Further studies showed that cultivating land that had been under *Stylosanthes* required less labour than cultivating land that had previously been cropped or fallowed.

Research on fodder banks carried out after 1987 is reported in Chapter 4 under two headings: *"Forage production and feeding systems"* (pages 121–124), and *"Legume forages in crop–livestock systems"* (page 153).

Semi-arid zone

The initial systems description phase of ILCA's programme in Mali was largely completed in 1981. The results were subsequently published in *ILCA Research Reports* (CIPEA Rapport de recherche n° 5, *Recherches sur les systèmes des zones arides du Mali: résultats préliminaires*, ILCA Research Report 13, *Productivity of transhumant Fulani cattle in the inner Niger delta of Mali*, and ILCA Research Report 14, *Livestock production in central Mali: Long-term studies on cattle and small ruminants in the agropastoral system*). The system description phase included studies of ecology, livestock production and human nutrition in a number of production systems. In 1983 the focus of the Programme's research shifted from diagnostic studies to the design and testing of improvements. Component research focused on agronomic trials to increase total dry-matter yields on arable land, the *embouche paysanne* system and improvements in the nutrition of work oxen in the late dry season. Monitoring of the pastoral production system continued.

Work in Mali after 1987 is reported in Chapter 4 under four headings: *"Management systems"* (page 124); *"Milk production and consumption in Mali"* (pages 109–111); *"Feeding strategies for draft animals"* (pages 133–134); and *"Range trends"* (pages 171–174).

During 1983 the Programme established research activities outside Mali. A substation was established at Niamey in Niger, where an ILCA staff member worked with ICRISAT. Rapid surveys of livestock demography and productivity were also carried out in 1982/83 in parts of Upper Volta (Burkina Faso) and Niger. In Upper Volta the work was carried out for the German Sahel Programme and was funded by GTZ, the German Agency for Technical Cooperation. In Niger the surveys were carried out at the request of the Niger Range and Livestock Project, which was supported by the United States Agency for International Development (USAID).

Also in 1983 a new research project was started in southern Mali. This focused on a smallholder livestock fattening programme, or *embouche paysanne*, funded by USAID. The work was carried out in collaboration with the Institut national des recherches zootechniques, forestières et hydrobiologiques.

Agropastoral system

Intercropping millet (*Pennisetum typhoides*) and cowpea (*Vigna unguiculata*) was thought to be a promising way of increasing the amount and quality of feed for livestock in the agropastoral system. Screening trials were conducted to identify more productive cowpea lines and agronomy trials investigated ways to increase the yield of cowpea both in pure stand and intercropped with millet.

At Banamba it was found that cowpea had to be planted at least six weeks after the millet to avoid reducing the grain yield of millet. A population of 25 000 cowpea plants per hectare was found to give the highest yields of both grain and straw. Planting on ridges 90 cm apart with 45 cm between hills and with one plant per hill gave the highest grain and dry-matter yields (Table 6).

Table 6. *Effect of planting geometry and number of plants per hill on cowpea yield at Banamba, Mali, 1985.*

Planting geometry	Plants per hill	Grain yield (kg/ha)	Hay yield (kg DM/ha)
90 x 45 cm	1	195	4028
	2	93	2288
90 x 23 cm	1	103	3915
	2	61	1934

Several highly productive cowpea lines were identified at Niono, despite the low rainfall at that site. In 1984, the highest-yielding accession (CSIRO 45581) yielded 517 kg of grain per hectare, compared with an average of 281 kg/ha for the 20 highest yielding accessions in the trial. A total of 81 accessions were tested at Niono and Banamba. The highest grain yield at Banamba was 1347 kg per hectare. Highest hay yields were 1.9 tonnes per hectare at Niono and 4.7 tonnes per hectare at Banamba. Many local farmers asked for seed of CSIRO 45581 and arrangements were made to multiply the seed.

Embouche paysanne

ILCA's studies on the *embouche paysanne* project started in 1984. The aims of ILCA's involvement were to assess the economic viability of the project and to develop technical improvement to the system.

The project was located in two areas, one (the Banamba area) to the west of the Niger river and the other (the Segou area) to the east of the river. Preliminary studies showed that both the buying and selling prices were higher in the Banamba area than in the Segou area in the 1983/84 season. Of the farmers sampled, 38% made losses, 44% made profits of less than US$ 10 per animal and about 18% made profits of more than US$ 10 per animal. Rates of return on investment appeared satisfactory for the Segou area but not for the Banamba area, due to the higher expenditure on non-family labour and fodder in the Banamba area.

Marketing of the 'finished' animals appeared to be one of the project's greatest problems. In 1984, 37% of finished animals had not been sold by June and 21% had not been sold by August.

In 1985 the study focused on detailed recording every three weeks of feeding and weight changes of 120 cattle and studies of the economics of the fattening system, including purchase and sale prices of cattle, costs of inputs and seasonal changes in prices on local markets.

Of the animals studied, 50.3% were Fulani Zebus, 45.5% were Maure Zebus and 4.2% were crossbreds. All were more than seven years old.

The cattle gained an average of 47 kg per head over a three-month fattening period, an average of 52 g/day. The Maure Zebus gained weight faster than the Fulani Zebus (0.77 vs 0.44 kg per day) despite similar feed intakes.

Bush hay, millet and sorghum straw and cottonseed residues comprised 84 to 97% of the animals' diets. Cottonseed residues were the largest component of the diets, comprising 40 to 60% (3.2 to 3.7 kg per day) of feed intake, depending on whether the animals were allowed access to grazing. Among zero-grazed animals, the diet included 7% millet straw, 10% sorghum straw and 35% bush hay. The cattle also consumed 31.9 kg of water per day.

In 1985 the 33 smallholders in the project made an average gross profit of 33 500 CFA francs (US$ 84) per animal from 108 animals, of which 67% was due to seasonal price increases and 27% to weight gain. The average net profit (after deducting costs of production) was 13 400 CFA francs (US$ 33.50) per animal.

While this average net profit appears to be satisfactory, 32% of the smallholders made no profit and 20% did not generate income to cover their costs of production (17 500 CFA francs or US$ 43.75 per animal). However, 54% of the smallholders made a net profit of more than 10 000 CFA francs (US$ 25) per animal. Similar results were found in 1986.

Sale price of the animals was found to depend solely on live weight: the quality of the carcass was apparently not considered in pricing.

The studies in 1985 had shown that the fattening programme depended heavily on cottonseed residues, which the smallholders had to buy in. An experiment in 1986 showed that, although reducing the amount of cottonseed residue fed reduced weight gain it increased profitability. Adding molasses/urea or cowpea haulm was not economically justifiable.

Nutrition of work oxen

The system study showed that work oxen were generally in poor condition at the end of the dry season, when they were needed for work. A series of experiments were carried out to investigate ways of improving the condition of oxen during periods when they worked most.

Trials showed that supplementing oxen with 2.5 to 5 kg of cowpea hay daily over the last three months of the dry season increased their work output during the tilling season by 16%. Supplemented animals were able to till 1737 m^2 per hour, compared with only 1498 m^2 per hour for unsupplemented animals.

Subsequent studies on this topic are reported in Chapter 4 under *"Feeding strategies for draft animals"* (pages 133–134).

The pastoral system

A major element of ILCA's work on the pastoral production system was completed in 1982. This was the ILCA/ODEM (Office du développement de l'élevage de Mopti) project, which focused on the pastoral system of the inner Niger flood plain and its surroundings.

In almost all pastoral societies animals are owned individually but the resources they consume — water and grazing — are communal. As a result, there is little control over access to these resources. The Niger flood plain system is unique in possessing social-territorial units that form the basis of a mechanism for controlling access to water and grazing.

However, these units, or *leyde*, were insufficiently defined and were not fully effective as a control system. It was not known whether the traditional access rights they bestowed were related to real carrying capacities and a rational use of the flood plain's resources. More sharply defined, and adjusted where necessary, the *leyde* might nonetheless serve as the basis for establishing pastoral units which would be fully recognised by the local community and used to enforce territorial grazing rights.

The object of the ILCA/ODEM project was to map the flood plain's land-use patterns and vegetation resources. ILCA compiled a series of maps based on interpretation of aerial photographs of the zone, while ODEM collected ecological and other field data needed to verify the maps. Data were processed at the Centre d'études phytosociologiques et écologiques in Montpellier, France.

The first series of maps produced showed *leyde* boundaries, trek routes, rights of access, camps and other man-made features over the 21 000 km^2 of the flood plain and its hinterland. The second series showed the different vegetation communities in the area. The final series gave a rough indication of the area's carrying capacity.

Together with information on cattle movements and numbers from aerial surveys, these maps provide the Government of Mali with a firm basis for livestock development activities in the Mopti area.

Monitoring range resources

In 1983 the Programme started an integrated study of the Gourma region of Mali. The project was conducted in collaboration with the National Aeronautics and Space Agency (NASA), USA, and NASA's Global

Inventory Monitoring and Modelling Section. Work included analysis of data from the advanced very high resolution radiometer (AVHRR) on board the NOAA-7 satellite and aerial surveys of the Gourma region.

The aim of the project was to test ways of using satellite-derived radiometric data to monitor important variables affecting livestock production, such as vegetation biomass and surface water resources. Routine records were taken at selected sites and regular aerial surveys were conducted to collect information to help interpret the satellite-derived data.

The area studied covered roughly 31 000 km^2 in the centre of the Gourma region, crossing the 200, 300, 400 and 500 mm rainfall isohyets. It thus corresponded with a broad range of bioclimatic conditions found in the Sahel.

The study of range resources centred on testing or "ground-truthing" normalised difference vegetation indices (NDVIs) derived from the red and infrared reflectances sensed by the satellite AVHRR. Analysis of data obtained in 1985 showed an indirect relationship between NDVI and vegetation biomass. The relationship between biomass and the integrated value of increments of NDVI over time was close: linear regression gave significant correlation coefficients of $r = 0.62$ for 25 sites and $r = 0.80$ for 13 sandy sites. Correlations of the order of 0.90 were obtained from studies in Niger.

ILCA's range monitoring studies in West Africa focused on the Gourma region of Mali.

Work in West Africa on satellite imagery was ended in 1986, in response to recommendations of the Second External Programme Review (as the QQR was renamed).

Ethiopian rangelands

The Ethiopian Rangelands Programme began in 1981 when monitoring of rangeland production systems was transferred to the Borana system in southern Ethiopia. Some work was done in the north-east of Ethiopia in 1982, but this work had to be abandoned because of increasing security problems in the region.

The Programme's studies focused on the Borana plateau, which covers 95 000 km^2 in southern Ethiopia and was one of the best-preserved pastoral areas in Africa. The plateau slopes gently from an altitude of 1500 m above sea level in the foothills of the Bale–Sidamo massif in the north to 1000 m near the Kenyan border in the south. Mean annual rainfall decreased from over 700 mm in the north-east to 400 mm in the south-eastern parts of the plateau. The main rains, accounting for 60% of the total rainfall, fall from March to May, while the "small rains" fall from September to November.

The Borana system is based on a group of permanent wells and a grazing area defined by water availability. During the dry season the Boran can graze their cattle in only a limited area around the permanent wells because of lack of water in other areas.

ILCA's research concentrated on approximately 16 000 km^2 of the Borana plateau, an area that in 1981 contained 90 000 people, 325 000 cattle, 125 000 small ruminants and some 30 000 camels.

Descriptive studies

Initial descriptive studies focused on water use, ecology and animal production.

Water-use studies

In 1982 studies were started on the utilisation of wells and ponds. Initially, 30 groups of wells were examined during the main dry season, from November to March. Eight of the more representative and important groups were then subjected to a more detailed survey during the short dry season from July to September. Data were collected on a wide range of parameters including the age, sex and origin of the majority of the livestock, the size and ownership of herds and flocks, water intake and quality, grazing orbits and labour requirements for watering livestock. Similar studies were conducted on the utilisation of ponds. These surveys led to a number of supplementary studies, for example on the effect of watering frequency and intake on cattle productivity and on the long-term effects of different grazing pressures on pasture production.

In 1983 the Programme started a four-year trial to study the effects of some of the management practices of pastoralists, including infrequent watering, long walking distances and night penning of animals.

After 27 months the effect of infrequent watering was small but statistically significant. While there were no significant differences in calving percentages or birth weights among cattle watered at one-, two- and three-day intervals, two- and three-day watering depressed weaning weights by 9 and 14 kg, respectively, compared with the weaning weights

Lifting water in a traditional Borana well.

of animals watered every day. However, there were no significant differences in the weights of animals at two years old.

In lactating cows, watering at three-day intervals reduced milk yield by 10% and increased loss of body weight and condition during the dry season. Most importantly, dry-matter intake fell by 9% in cows and by 10 to 15% in steers but no increases in digestibility were observed.

The main advantages of watering animals every three days were that water and feed were conserved and that the pastoralist could exploit feed resources further from the watering point. Watering the animals every third day reduced water consumption by 25% compared with watering every day. On the Borana plateau this represents a saving of 1.2 million tonnes of hand-lifted water each year, significantly reducing the amount of labour required to water animals. The lower dry-season feed consumption could either prolong the availability of dry-season feed or, as in the Borana area, allow a higher stocking rate, while the exploitation of distant grazing resources allows a further increase in stocking rate or reduces overgrazing near to water.

In 1986 the trials were modified to include walking and night enclosure, since these are normal husbandry practices in pastoral areas. Walking 40 km every third day had little effect on the productivity of breeding and growing cattle, despite being continued throughout the dry season and totalling more than 3000 km. Walking apparently had little effect on milk yield, as indicated by the lack of differences in weaning weights between calves from dams that walked or did not walk. Weaners that walked were 20 kg lighter at 19 months old than were those that did not walk, although much of this weight difference had disappeared by the time the animals were two years old.

Ecology studies

Tree and shrub encroachment on open grazing areas was thought to be of increasing importance in the Borana plateau. In some parts more than 30% of the area had 40 to 60% tree cover in 1983 and only in the north did more than 25% of the land have tree cover of less than 20%. The Programme started detailed studies of the dynamics of bush encroachment at three sites in the Sidamo area in 1984.

The results of the studies suggested that depletion of soil minerals was not a trigger for tree invasion, as had previously been thought, but that it accompanied the invasion of bush. In areas invaded by bush, soil degradation was not noticeably altered and between 26 and 48% of the edible biomass was in the form of bush leaves and branches. In some cases the availability of grass was reduced by as much as 70%, even where the total grass/browse biomass was greater than the previous grass biomass alone.

Animal production

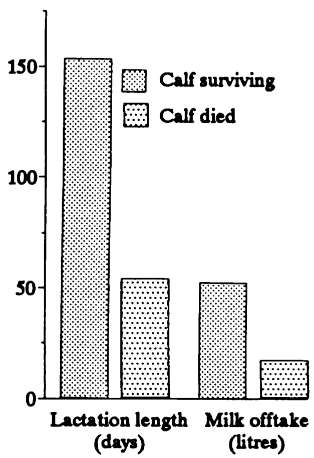
Studies showed that the Borana pastoral system produced calves weighing 18 kg at birth, compared with a birth weight of 28 kg achieved under ranching conditions with similar animals. The final three months of pregnancy coincided with peak stress in the dry season, and there appeared to be little opportunity to alleviate this. Weaning weights at 210 days old averaged 48 kg, whereas the breed potential is at least 180 kg. Offtake of milk for human consumption was the main reason for the low weaning weights and supplementation of calves was expected to achieve high returns.

Calving rate was found to be 75%. The lactation curve for cattle was bimodal, with a mean yield of 922 kg over 320 days and a median yield of 680 kg over 210 days. Some 30 to 38% of total milk yield was taken for human consumption. Sixty per cent of calves were born in the April/May "main rains" period, and lactations starting at this time provided 31% more milk and resulted in calves that were 16 to 23 kg heavier than those born during the October/November secondary rains.

The stress period at two to four months old appears to be of more importance than later stress. Lactations starting in March/April came to an abrupt end after the rains, probably due to increased foetal demand, whereas lactations beginning in October tended to decrease more slowly and were important in carrying pastoralists through the long dry season. The two lactation types were the result of a dual strategy whereby cows giving birth in March/April were managed so as to conceive again early and so provide fresh annual supplies of milk, whereas cows giving birth in October/November were allowed to have longer calving intervals but provide dry-season milk supplies. Calf mortality rates ranged from 10 to 23% in "normal" years.

In 1983 the Programme started a trial aimed at determining the effects of calf supplementation on calf growth and survival. In 1984 the area suffered a severe drought. Rainfall had been low in 1983, and the main rains in April and May 1984 failed. Herd mortalities more than doubled in 1984; 50 to 70% of the breeding herd died or were sold for grain and most of the calves died. In the calf feeding trial, sufficient fodder was grown to feed the calves up to 150 days of age. The calves were otherwise managed under traditional conditions.

Figure 16. *Effect of calf survival on lactation length and milk offtake.*



Fifty-nine per cent of the supplemented calves survived to 120 days old, compared with only 9% of the unsupplemented calves. However, the trial indicated that supplemented calves needed extra water if they were to gain full benefit from the supplementation.

Further results from this work are reported in Chapter 4, *"Calf rearing strategies"* (page 101).

It was also found that calf survival had a marked effect on milk output of their dams. Dams of calves that survived had lactations that were three times as long and produced three times as much milk as cows whose calves died (Figure 16).

Weighing a Boran calf in southern Ethiopia. ILCA studies showed that calf performance in the Borana system was well below breed potential.

In a model of drought recovery, the reasonable calf survival rates achieved in the calf feeding trials resulted in self-sufficiency of the pastoralists in the first post-drought year and allowed herds to recover to pre-drought numbers and offtake to reach pre-drought levels in the second year following the drought, compared with 7 to 12 years after the drought with traditionally managed herds. Thus, supplementary feeding of calves had implications for drought mitigation and recovery as well as for productivity in normal years.

Pilot forage production trials in 1984 showed that forage yields of up to one tonne of forage dry matter per hectare were possible even in a drought year. In the post-drought year of 1985, yields of cowpea, pigeon pea and *Lablab* ranged from 3 to 7 t DM/ha in the main dry season, while *Stylosanthes scabra, S. hamata* and *S. guianensis* yielded 2 to 3 t DM/ha and maize yielded up to 5 t/ha. These results showed the potential for forage crops and indicated that maize cropping would be possible on a limited scale in better-watered areas.

Kenyan rangelands

In 1980, ILCA's Kenyan Rangelands Programme selected three group ranches in Kajiado District as the focus of its research. These were the Olkarkar, Merueshi and Mbirikani ranches. A comprehensive report describing the Maasai group ranch production system was published as

ILCA Systems Study 4, *Maasai herding: An analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya.* The majority of the study was made between 1981 and 1985.

The Maasai livestock production system

The study aimed at providing a detailed description of the Maasai's production system, in order to determine the causal relationships among its components, to identify constraints to increasing livestock productivity and to design and test possible interventions.

The study focused on an area of about 1600 km^2 with a population of about 3500 people in 326 households. The area supported a livestock population of 53 000 cattle and 29 000 small ruminants. The availability of grazing varied from 1.7 ha/tropical livestock unit (TLU; 1 TLU = 250 kg live weight) in the more favourable areas to 4.3 ha/TLU in the drier areas in the south of the study area.

Determinants of producer strategies

The location and wealth of the producer were the two most important factors determining producer's strategies and decisions with respect to grazing, watering, milk offtake and sales and exchanges of animals. The northern part of the study area received more rainfall (500 to 700 mm per year) than the southern part (300 to 400 mm), which experienced longer dry seasons and more frequent droughts. Consequently, Maasai in the north were more sedentary and had much smaller grazing orbits than those in the south, who split their herds, sending dry animals to distant pastures over extended dry periods. Producers in the north had greater access to markets, facilitating the sale of animals, especially small ruminants, and the purchase of consumables and veterinary drugs. In addition, those in the north, who belonged to the Kaputiei subtribe, had been more exposed to outside influences than the Kisongo in the south, who were more traditional in their behaviour, living in large encampments and cooperating more in herding and exchanging animals.

The wealth of producers, measured by the size of livestock holding per person, varied considerably. Rich households had 8 to 10 times as many cattle as poor households and five times as many small ruminants. Poor households owned more small ruminants than cattle, whereas the opposite was the case for rich households. The mean numbers of cattle and small ruminants per household were 132 ± 151 and 63 ± 67, respectively.

Range productivity

Due to the extreme variability of rainfall during the study period, the availability of forage varied greatly among seasons and years as well as between the northern and southern parts of the study area. In good years, standing biomass exceeded 2 t DM/ha per month for six months and the grazing diet was likely to exceed 7% crude protein and over 50% digestibility for seven months. In poor years, grazable biomass exceeded 1 t DM/ha per month for only two months. Most seasons between 1981 and 1984 fell between these two extremes, the northern ranches experiencing more favourable conditions than the southern ranch. In September 1983, the driest month studied, cattle managed to consume forage that contained 4.7% crude protein and that was 44% digestible.

Grazing pressure was uneven across the study area, ranging from a high of 1 ha/TLU to a low of 35 ha/TLU, and decreased sharply along the rainfall gradient from north to south. Factors that contributed to this large variation were: (a) unequal distribution of vegetation due to edaphic conditions, (b) clustering of homesteads near permanent water sources and (c) differential rights of individual households to reserved grazing areas. The study period coincided with a peak of livestock population following a steady build-up of animal numbers since the big crash after the 1974–76 drought.

Cattle productivity

Maasai herds were characterised by low mortality in adults and calves, low calving rates, low growth of calves and low milked-out yields (Table 7), resulting in low productivity indices. The productivity of the Maasai system was higher than the output of 17 kg/100 kg cow live weight obtained in traditional transhumant Fulani herds in the Niger flood plain but lower than that of commercial ranches in Tanzania (32 kg) and Kenya (35 kg) in similar climates. However, low productivity per animal was offset by high stocking rates, giving high productivity per unit of land.

Table 7. *Productivity of Maasai herds.*

Mortality rate (%)	
Adults	5
Calves	11
Calving rate (%)	58
Calf weight at one year old (kg)	95
Milked-out yield (kg/lactation)	260
Productivity index	
kg calf live weight/cow per year	64
kg calf live weight/100 kg cow live weight per year	25

Small ruminant productivity

The productivity of sheep and goat flocks was very low, ranging from 107 g of weaned lamb/kg of flock biomass in sheep in the northern area to only 29 g/kg of biomass in goat flocks in the southern area. This poor

A Maasai herder with his animals. ILCA's studies focused on group ranches in Kajiado District, Kenya.

performance was attributed to very low birth rates (25–70%) and very high pre- and post-weaning mortalities of 20 and 35%, respectively.

Utilisation of livestock production

The average gross output of the Maasai livestock production system from 1981 to 1983 was estimated to be 3800 kg of milk and 7100 kg of meat per household per year. Net output was worth about US$ 2715 per household and US$ 270 per person. This corresponded to US$ 7.40/ha or US$ 19.90/TLU. The net output of large-scale (rich) producers was worth US$ 5370 per household or US$ 370 per person, while that of small-scale (poor) producers was valued at US$ 1290 per household or US$ 160 per person. However, these figures represent the levels attainable during good years when the livestock population is high. During droughts the net output of the system is negative.

Overall, 27% of gross output was consumed in the home, 28% was sold and 45% was used for stock accumulation. However, there were significant differences in partitioning between producers of different wealth classes. For small-scale producers, home consumption accounted for the largest proportion (42%) of gross annual output and stock accumulation accounted for the smallest proportion (20%). Conversely, for large-scale producers stock accumulation accounted for the largest proportion (56%) and home consumption the smallest (20%).

Institutional constraints

In addition to the environmental constraints on livestock productivity there were a number of institutional constraints that contributed to the poor welfare of the Maasai pastoralists. The most important of these were low producer prices, an undeveloped market for small ruminants and the ineffectiveness of group-ranch management.

The terms of trade (purchasing power) of Maasai pastoralists had been declining since 1975, reaching a low of 71% in 1982 before increasing to 75% in 1983 (1975 = 100%). Meat prices were regulated by the Kenyan Government and had not kept abreast of increases in the prices of other commodities. Studies showed that no technological improvement could match the dramatic effect that a price realignment would have had in increasing the income of the Maasai. The lack of a market for smallstock limited commercial offtake. This was reflected in the high proportion of old castrates and infertile females in flocks far from markets.

The group ranch was a new form of social organisation for the Maasai, involving an alien concept of decision-making and enforcement by a committee of elected representatives. The system did not function well and was an aggravation to many Maasai, who were attempting to break up the group ranches in favour of individual holdings.

Central research and support units

The period after the first QQR of ILCA saw a considerable development and strengthening of central research and support units. This reflected the move away from systems description towards component research aimed at overcoming constraints identified in the first phase of research. The main central research and support units were the Livestock Productivity and Trypanotolerance Group, the Livestock Economics Unit, the Forage Agronomy Section, the Small Ruminant and Camel Group, the Nutrition Unit, the Aerial Survey Unit, the Computer Unit, Library and Documentation Services, Training and Publications.

Livestock Productivity and Trypanotolerance Group

Following the study in cooperation with the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP), on the use of trypanotolerant cattle, sheep and goats in West and central Africa, ILCA and the International Laboratory for Research on Animal Diseases (ILRAD) set about establishing the African Trypanotolerant Livestock Network. By 1986 there were 11 sites in seven countries participating in Network research (Table 8). Detailed analyses were carried out in 1986 of data covering the period 1 January 1984 to 31 December 1985. Data were available from eight sites: Kolo (Zaire), Avetonou (Togo), Sokode (Togo), Tengrela (Côte d'Ivoire), Boundiali (Côte d'Ivoire), OGAPROV (Office gabonais d'amélioration et de production de viande, Gabon), Mushie (Zaire) and Muhaka (Kenya).

Work after 1987 on trypanosomiasis and trypanotolerance is reported under *"Trypanotolerance Thrust,"* Chapter 4 (page 155 *et seq*).

Table 8. *Tsetse and livestock populations at African Trypanotolerant Livestock Network sites in 1986.*

Site	Country	Tsetse group	Relative tsetse challenge	Livestock		
				Species	Type	Management system
Kolo	Zaire	palpalis	Zero	Cattle	Trypanotolerant	Ranch
Avetonou	Togo	palpalis	Zero/low	Cattle	Trypanotolerant	Ranch and village
				Sheep	Non-trypanotolerant	Village
Sokode	Togo	palpalis	Low	Sheep and goats	Trypanotolerant	Village
Tengrela	Côte d'Ivoire	palpalis	Low	Cattle and sheep	Trypanotolerant and non-trypanotolerant	Village
Boundiali	Côte d'Ivoire	palpalis	Medium	Cattle and sheep	Trypanotolerant and non-trypanotolerant	Village
Idiofa	Zaire	palpalis and fusca	Low	Cattle	Trypanotolerant	Village
OGAPROV	Gabon	palpalis and fusca	Medium	Cattle	Trypanotolerant and non-trypanotolerant	Ranch
Mushie	Zaire	fusca	Medium/high	Cattle	Trypanotolerant	Ranch
Muhaka	Kenya	morsitans and fusca	Low	Cattle	Non-trypanotolerant	Village
Ghibe	Ethiopia	morsitans and palpalis	Low	Cattle	Non-trypanotolerant	Village
ITC[1]	The Gambia	morsitans and palpalis	Low and medium	Cattle	Trypanotolerant	Village

1. ITC = International Trypanotolerance Centre.

Tsetse challenge

Tsetse challenge was measured as the product of tsetse relative density and the trypanosome infection rates in tsetse, modified, where possible, by the proportion of "feeds" the flies had taken that were from domestic livestock. For the eight sites, mean tsetse relative density during 1984 and 1985 ranged from 0.1 to 6.8 flies/trap per day and mean infection rate from 0.0 to 16.3%, giving a range of tsetse challenge from 0.0 (Kolo) to 86.2 (Mushie). At selected sites, tsetse blood-meal analysis was used to estimate the proportion of feeds taken on cattle. For example, at Mushie the proportion of feeds on cattle was 0.43, giving a modified tsetse challenge of 37.1.

Trypanosome prevalence

Trypanosome prevalence (the percentage of animals determined as being parasitaemic at the monthly recording) was the Network's measure of trypanosome infection rate in livestock. Across the eight Network sites there was then no clear relationship between mean monthly estimates of tsetse challenge and overall trypanosome prevalence, with all trypanosome species considered together. The lack of a relationship was due, in part, to differences in tsetse species among sites. Local variation in tsetse challenge was also important.

Factors influencing trypanosome prevalence included the livestock species. N'Dama cattle had about two to three times more infections than Djallonke sheep when maintained together, while Djallonke sheep and Dwarf West African goats had the same level of infection. Cattle breed also had an important effect on trypanosome prevalence, with major differences shown at OGAPROV (N'Dama 8.8%, Nguni 25.9% and N'Dama x Nguni 16.5%) and between trypanotolerant and zebu crossbred populations at Boundiali and Tengrela. Trypanosome prevalence was consistently lower in the trypanotolerant breeds.

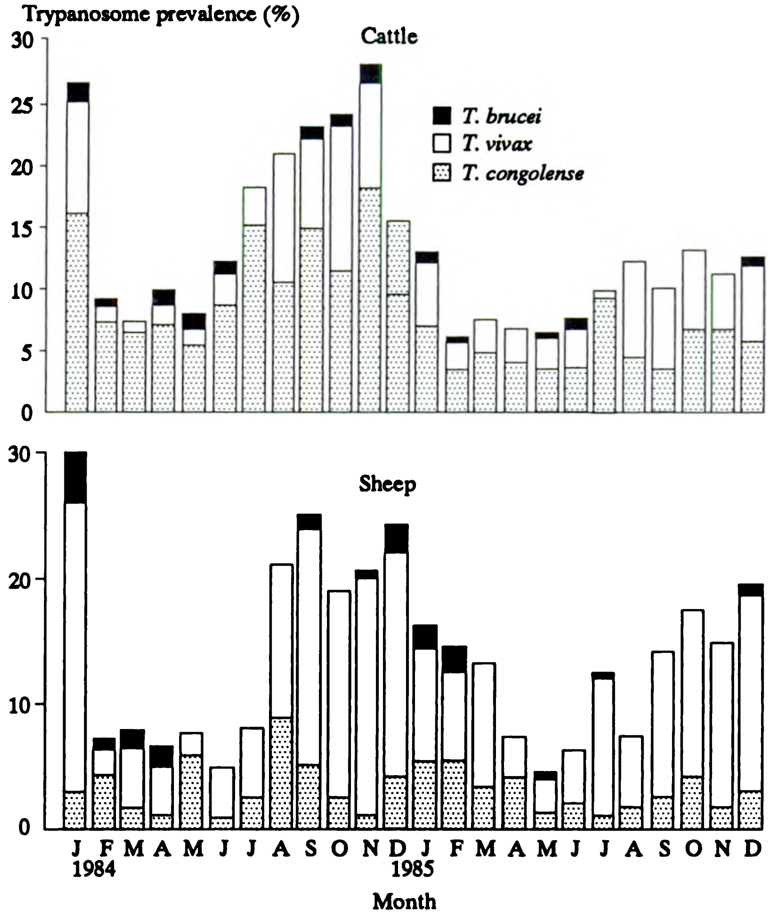
Species and intensity of trypanosome infection

Trypanosome infections are identified by the causal species (*Trypanosoma congolense, T. vivax* and *T. brucei*) and the intensity quantified by a parasitaemia score. Important differences were found among livestock species, breeds and age groups for the proportion of infections due to the trypanosome species *T. congolense* and *T. vivax*.

Trypanosoma congolense infections were more frequent in cattle and *T. vivax* infections were more frequent in sheep (Figure 17). The species and intensity of infection were the same in goats as in sheep. Livestock

N'Dama cattle in Zaire.

Figure 17. *Infections by trypanosome species in cattle and sheep, Boundiali, Côte d'Ivoire, 1984–85.*



species did not seem to affect the intensity of infection, which was higher in *T. vivax* than in *T. congolense* infections.

In Côte d'Ivoire, frequency of *T. congolense* infections was higher in zebu cattle than in trypanotolerant breeds, and in Gabon the more-susceptible Nguni had a higher frequency of *T. congolense* infections than did the N'Dama and N'Dama x Nguni. The Nguni had the highest intensity of infection and the N'Dama the lowest.

Results from seven Network sites showed the important effect of animal age on the infecting trypanosome species. The proportion of *T. vivax* infections decreased with age, with calves generally having more *T. vivax* infections than *T. congolense* infections, while the reverse was true in cows. The same effect was observed in sheep.

Trypanosome infection and PCV

A major clinical symptom of trypanosomiasis is anaemia, estimated by blood packed red cell volume (PCV), which is recorded monthly at

Network sites. A low PCV indicates anaemia. Results for PCV of cows at three Network sites are summarised in Table 9. Mean PCV of uninfected cows varied between sites by two to four percentage points (overall mean 32.8%), but responses to trypanosome infection were similar, a depression of 6.8% on average (2.2 percentage points). Initial results from Mushie indicated that there was no difference in pathogenicity between *T. congolense* and *T. vivax* infections. Frequency of infection was more important. PCV was depressed by one to 1.5 percentage points (3 to 4%) by one *T. congolense* or *T. vivax* infection and by four percentage points (11%) by two or more infections. The effects of trypanosome infection on ewe PCV were consistent with those for cattle. However, PCV means were lower in sheep than in cattle.

Breed had important effects on PCV. Among cows exposed to trypanosomiasis at the OGAPROV site the N'Dama Okouma strain had the highest PCV (33.3%), the N'Dama Senegal strain an intermediate PCV (31.3%) and the more-susceptible Nguni the lowest PCV (30.5%). N'Dama x Nguni cows had a PCV of 31.6%.

Lactation, calf sex and animal age also had important effects on PCV: Lactation depressed PCV by about two percentage points; the PCV of female calves was about one percentage point higher than that of male calves; and cows had higher PCV than calves when not exposed to trypanosomiasis (Kolo) but calves had marginally higher PCV than cows when exposed to trypanosomiasis (Mushie). This age x trypanosomiasis-risk interaction for PCV indicates the persistence of PCV depression resulting from trypanosome infection.

The repeatability of the monthly PCV measured in cattle in contrasting situations ranged from 0.26 to 0.36, indicating the possibility of a heritability estimate adequate for a selection programme for trypanotolerance. The study identified the need to determine the most appropriate selection criterion based on PCV. Repeatability of trypanosome infection was low with no possibility of selecting directly against susceptibility to trypanosome infection.

Trypanosome infection and livestock productivity

Viability of trypanotolerant cattle exposed to trypanosomiasis was at least as good as that in comparable management systems in tsetse-free areas, including that of N'Dama cattle at no trypanosomiasis risk at Kolo. At the OGAPROV site the more-susceptible Nguni cattle had higher trypanosome prevalence and lower viability than N'Dama and N'Dama x Nguni cattle. The viability of sheep and goats was lower than that of cattle when exposed to trypanosomiasis risk, although it was thought likely that factors other than trypanosomiasis were responsible.

Reproductive performance of trypanotolerant cows and ewes that had been infected with trypanosomes post-partum was consistently lower than that of females that had not been infected. The poorer performance was not associated with any important live-weight loss.

Table 9. *Percentage depression of PCV traits in cows following trypanosome infection at three Network sites with medium or high trypanosomiasis risk.*

		Average PCV in gestation (%)		PCV at parturition (%)		Average PCV in the lactation (%)		PCV at weaning (%)		Overall	
Site	Trypanosome prevalence	Mean	Per cent depression	Mean	Per cent depression	Mean	Per cent depression	Mean	Per cent depression	Mean	Per cent depression
Boundiali	13.1	33.0	7.6	31.4	9.2	30.8	4.5	30.6	5.9	31.5	6.8
Mushie	8.8	35.2	6.0	34.1	6.5	35.2	7.1	35.0	6.0	34.9	7.1
Avetonou	7.2	33.5	5.7	30.6	3.9	32.0	6.3	32.2	12.4	32.1	7.1
Overall:											
Mean		33.9		32.0		32.7		32.6		32.8	
Per cent depression			6.4		6.5		6.0		8.1		6.8

In trypanotolerant cattle and sheep, trypanosome infections during gestation and/or lactation did not have a large effect on live weights at parturition and weaning nor on live-weight change during the lactation/suckling period. Performance was depressed by 3 to 5% by infections suffered by the animal itself, while infection in the cow during the last six months of gestation significantly depressed calf birth weight.

The study also examined possible relationships between PCV and livestock performance. Post-partum PCV was related to reproductive performance, low PCV being associated with lower performance and high PCV with higher performance. However, there was no consistent relationship between PCV and live-weight traits in cattle and sheep, although in general low PCV was associated with poorer performance and high PCV with better performance. The strongest relationships, between PCV and weaning traits in cattle, were also shown at Kolo, where there was no trypanosomiasis risk.

The limited effect of trypanosome infection on the performance of these populations confirmed their trypanotolerant status.

Use of trypanocidal drugs

Chemoprophylactic drug programmes were tested on East African Zebu cattle in village herds at Muhaka, Kenya. Initial results from the first 24 months of the comparison showed that treatment with the trypanocidal drug reduced detectable parasitaemia by 39% and increased PCV and daily weight gain of non-parasitaemic animals. For example, the daily weight gain of weaned calves increased from 42 to 82 g/day. The beneficial effect of trypanocidal drugs appeared to decline gradually during the three months following treatment.

Livestock productivity studies

Between 1981 and 1986 the Livestock Productivity and Trypanotolerance Group collaborated with scientists from several national programmes in Africa in the analysis of animal production data. These studies included:

- *Evaluation of the productivities of Djallonke sheep and N'Dama cattle at the Centre de recherches zootechniques, Kolda, Senegal*, by A. Fall, M. Diop, J. Sandford, Y.J. Wissocq, J. Durkin and J.C.M. Trail (ILCA Research Report 3)

- *Productivity of Boran cattle maintained by chemoprophylaxis under trypanosomiasis risk*, by J.C.M. Trail, K. Sones, J.M.C. Jibbo, J. Durkin, D.E. Light and M. Murray (ILCA Research Report 9)

- *Crossbred dairy cattle productivity in Arsi region, Ethiopia*, by G.H. Kiwuwa, J.C.M. Trail, M.Y. Kurtu, F. Anderson and J. Durkin (ILCA Research Report 11).

Other studies covered cross-breeding of N'Dama with Sahiwal cattle at Teko Livestock Station, Sierra Leone; the productivity of Zebu Gobra cattle at the Centre de recherches zootechniques de Dahra, Senegal; and cross-breeding of range beef cattle at the Matopos Research Station, Zimbabwe.

Subsequent work in this field is reported in Chapter 4 under *"Breed evaluation and improvement"* (pages 111–114) and *"Genetic resource evaluation and breed improvement"* (pages 117–121).

Livestock Economics Unit

ILCA established a Livestock Policy Unit in 1982, and a Systems Research Unit in mid-1984. These two units were merged in 1985 to form the Livestock Economics Unit.

ILCA became involved in policy research because it was clear that neither lack of financial and manpower resources nor the absence of well-adapted new technology by themselves adequately explained the poor performance of sub-Saharan Africa's livestock sector. There was a growing realisation that, in many cases, inappropriate government policies were constraints that would still hinder the livestock sector's performance even if technology and resources were available.

Two requirements were identified: firstly, the need to carry out research on livestock policy issues, and secondly the need to communicate the results of this research to policy makers in a direct and clear way. This second need led to the establishment, in 1985, of the African Livestock Policy Analysis Network, an information-sharing network aimed at providing a forum through which those involved in the livestock sectors of African countries could exchange views and learn from others' experiences.

The Unit pursued four main policy research areas up to 1986:

- Financing of livestock services
- The effects of imports of dairy commodities on domestic production, consumption and welfare
- Dairy marketing systems and
- Pricing policies.

Work on dairy policies and economics after 1987 is reported in Chapter 4 under *"Cattle Milk and Meat Thrust"* (page 100 *et seq*).

Financing livestock services

By the end of 1984 fairly complete data had been assembled on 16 countries (Table 10). While the livestock sector accounted for an average of about 27% of total agricultural gross domestic product (GDP) it

Table 10. *Financing and staffing of livestock services in sub-Saharan Africa.*

Country	Government recurrent expenditure on livestock services		Staffing ratios in animal health services			Livestock GDP as a % of agricultural GDP in 1982[d]	1982 GNP per caput (US$)
	US$[a]/ TLU[b]	As % of all agricultural services	Staff costs as % of all costs	'000 TLU per high-level staff[c]	Low- and medium-level staff per high-level staff[c]		
Benin	0.9	n.a.	81	41	8	12	310
Botswana	1.6	51	21	57	10	n.a.	900
Burkina Faso	0.2	16	91	210	15	29	210
Chad	0.3	4	81	141	13	37	80
Côte d'Ivoire	8.4	n.a.	74	18	9	3	950
Ethiopia	0.1	11	66	355	17	29	140
Kenya	2.0	27	69	66	16	40	390
Malawi	3.7	23	34	40	26	6	210
Mauritania	3.1	9	63	289	15	95	470
Niger	n.a.	8	61	120	13	29	310
Senegal	1.4	n.a.	85	13	4	29	490
Sierra Leone	1.8	5	29	18	3	7	390
The Gambia	n.a.	3	70	n.a.	n.a.	21	360
Togo	0.8	2	92	10	3	11	340
Zambia	3.4	4	45	81	3	37	640
Zimbabwe	n.a.	19	48	73	7	33	850

Most of the undated data were for 1978/79 but a few were from 1974/75.

a. In 1970 constant prices.

b. TLU = tropical livestock unit (250 kg live weight).

c. High-level staff are veterinary surgeons and their equivalents.

d. Assumes that the ratio between the value of inputs and the value of outputs in the livestock sector was the same in 1982 as in 1975.

received only 11% of the funds spent on agricultural services as a whole. Thus governments were neglecting their livestock sectors.

There was no correlation between the importance of the livestock sector in a country's agricultural GDP and the share it received of the government's agricultural budget. Nor did the richer countries allocate a bigger share of their agricultural budget to livestock in recognition of the higher share of livestock products in food consumption as wealth increases. However, in terms of absolute expenditure per head of livestock, richer countries did spend more on their livestock services, and in most of the countries reviewed expenditure per head of livestock increased during the 1970s in constant US$ terms, although in about one third of these countries the increase was caused as much by a decline in the livestock population as by an increase in aggregate expenditure.

This apparent increase in government expenditures on livestock needs to be viewed alongside a possible decline in the quality of services provided. One indication of quality is the relationship between staff and non-staff costs in total expenditure. A rough rule-of-thumb is that when staff costs take up more than half the total budget there is not enough left for the supply of vaccines, drugs, transport and other materials needed for the staff to be really effective. In over half of the countries reviewed, the proportion of the total budget spent on staff costs rose significantly in the 1970s. There was no evidence that the rise in the proportion of staff costs reflected better-qualified staff or a better quality of service.

Imports of dairy products

A study of imports of dairy products into sub-Saharan Africa showed that in the mid-1980s about one in every four litres of milk (or its equivalent in other dairy products) consumed in sub-Saharan Africa had been imported. In West and central Africa the proportion was about one in two, and in some countries, such as Côte d'Ivoire and Nigeria, the proportion was two or more in every three.

The scale of imports into individual countries could not be adequately explained by exogenous factors such as growth in human population, per caput incomes or domestic dairy production.

A case study in Mali showed that dairy imports — one-third of them as food aid — accounted for about 20% of all the milk consumed in the country. An estimated 65% of the imports were consumed in the capital, Bamako, where they accounted for 90 to 95% of the milk and dairy products consumed.

The government policy was to provide consumers in Bamako with dairy products at 'reasonable prices' while stimulating local milk production by spending the revenues from sales of dairy food aid on dairy development. However, the study indicated that the strategy was not effective: consumer welfare had not increased and the measures to stimulate milk production had not had a significant effect. Retail prices for dairy products in Bamako were distorted by government policy,

Taking milk to market in the Ethiopian highlands. ILCA's studies showed the importance of proximity to an urban centre or to a milk collection centre.

which favoured consumption of milk powder. As a result, milk powder accounted for nearly half of all the dairy imports.

The full findings of the study on dairy imports were subsequently published as ILCA Research Report 17, *Dairy imports into sub-Saharan Africa: Problems, policies and prospects*.

Dairy marketing systems

In 1985 the Livestock Economics Unit surveyed milk acquisition by households in Addis Ababa, and in 1986 the Unit studied the sales patterns of milk producers in and around Addis Ababa.

Over 70% of the households surveyed either seldom or never acquired milk. Of those that did acquire milk, 90% bought it and 10% kept their own cows. Income had a strong effect on whether a household acquired milk: in the city, only 23% of lower-income households — those with an income of less than 250 Birr a month — regularly acquired milk, compared with half of the higher-income households. The difference was even more marked in households on the outskirts of the city: 70% of the higher-income families regularly acquired milk, compared with only 24% of lower-income families.

Some 70% of the milk bought by households in Addis Ababa was bought directly from producers, almost all of whom kept their animals within the city limits.

The study of producers' markets showed that intra-urban producers, peri-urban large-scale producers and those peasant producers living near Addis Ababa with easy access to a government milk collection centre all operated rather monetised dairy enterprises, selling about 70% of all the milk they produced (including that taken by the calf). Peasants further from collection centres or from Addis Ababa had a more subsistence-oriented system, selling less than half the milk they produced.

The proportion of milk sold fresh, rather than as butter or cheese, appeared to be affected by the ease with which producers could sell their milk. Relative prices of milk, butter and cheese had less of an influence on the form milk was sold in.

Ease of access also affected the proportion of milk sold through different outlets. Intra-urban producers sold mostly to consuming households, while peri-urban producers sold to coffee houses, hotels and restaurants. The government Dairy Development Enterprise was the major purchaser of peasant producers' milk.

The results of the marketing study were subsequently published as ILCA Research Report 19, *Dairy marketing in Ethiopia: Markets of first sale and producers' marketing patterns.*

Forage Agronomy Section

The Forage Legume Agronomy Group, which later became the Forage Agronomy Section, was established at ILCA's headquarters in 1982. The major work of the Section up to 1986 was in developing ILCA's forage germplasm collection. In 1982 the Section collected species of Leguminosae in Ethiopia, concentrating mainly on collecting species of *Trifolium*. The Section also received germplasm from the collections of the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia), the International Centre for Tropical Agriculture (CIAT, Colombia), the International Center for Agricultural Research in the Dry Areas (ICARDA, Syria), the International Maize and Wheat Improvement Center (CIMMYT, Mexico) and the national collection of Belize. By the end of 1986 the collection comprised over 9000 accessions.

Further collection missions were made in Ethiopia in 1983, in Ethiopia, Kenya and Niger in 1984, in Tanzania in 1985 and in Ethiopia, Burundi, Rwanda and Zaire in 1986. Most of these collection missions were in collaboration with, and supported by, the International Board for Plant Genetic Resources (IBPGR), one of ILCA's sister centres in the CGIAR (Consultative Group on International Agricultural Research) system. In 1985 IBPGR designated ILCA as the centre to hold base collections of a number of forage species, including members of the genera *Neonotonia*, African *Trifolium*, *Cenchrus* and *Digitaria*. The controlled-environments seed store, drying facilities and ancillary laboratories for the genebank were completed in 1987.

Other activities of the Forage Agronomy Section focused largely on screening and evaluating forage germplasm at several sites in Ethiopia and Nigeria, multiplying seed of promising accessions, the agronomy of forages, particularly legumes, and networking, including the FNE — in collaboration with the Plant Genetic Resources Centre/Ethiopia — and PANESA, which was established in 1985 with funding from the International Development Research Centre, Canada.

One trial that ran from 1984 through 1986 evaluated the agronomic characteristics of 96 accessions of six native Ethiopian *Trifolium* species (*T. decorum, T. quartinianum, T. rueppellianum, T. steudneri, T. bilineatum* and an unnamed species). The main characters recorded were days to first flowering and dry-matter and seed yields.

The trial showed wide ranges between species and between accessions within species. In 1984, for example, the number of days to flowering ranged from 54 to 111. Flowering was affected by rainfall, and seemed to be related to the rainfall at the site of origin (Table 11). Early-flowering accessions came from lower-rainfall areas, while late-flowering accessions came from higher-rainfall areas.

Forage yield was less sensitive to rainfall than flowering but was still related to rainfall at the site of origin. Mean dry-matter yield in 1984, for example, ranged from 3700 to 7800 kg/ha, *T. rueppellianum* ILCA 9955 giving the lowest yield and *T. quartinianum* ILCA 6301 giving the highest yield. The results across years indicated that these species and

Clovers growing in evaluation plots at ILCA's headquarters site, Addis Ababa, Ethiopia.

Table 11. *Rainfall at the site of origin and days to first flowering of* Trifolium *species grown at Shola, Ethiopian highlands, in 1984.*

Species	ILCA no.	Mean rainfall at site of origin	Days to first flowering
T. decorum	6264	1600	107
T. quartinianum	9378	1000	65
T. rueppellianum	6290	1250	69
Trifolium sp	9452	1750	111
T. steudneri	6261	860	54
T. steudneri	9380	1250	70
T. tembense	7102	1050	66
T. tembense	10181	1500	108

Source: Adapted from: Kahurananga J and Tsehay A. 1991. Variation in flowering time, dry matter and seed yield among annual *Trifolium* species, Ethiopia. *Tropical Grasslands* 25:20–25.

accessions needed rainfall of at least 1000 mm to achieve good biomass production, but at least 1300 mm for good flowering and seed production in accessions from high-rainfall areas.

The results indicated wide genetic variation in the clovers studied, which thus offer material from which to select material to suit different climatic conditions in other parts of the African highlands.

A trial in 1983 with nine *Trifolium* species showed the dramatic effects of applying even relatively small amounts of phosphorus to clovers (Table 12). The six Ethiopian native clovers far outyielded the exotic clovers included in the trial. *Trifolium quartinianum* gave the highest yield, and showed the greatest response to P fertiliser, yield trebling with an application of only 5 kg P/ha and rising to fivefold with an application of 10 kg P/ha.

Work on forages conducted after 1987 is largely reported Chapter 4 under *"Animal Feed Resources Thrust"* (page 136 *et seq*).

Networks

ILCA established a number of other networks between 1981 and 1986. These included a network focusing on small ruminants and camels, operated by the Small Ruminant and Camel Group, and the African Research Network on Agricultural Byproducts, in which ILCA's Nutrition Unit was closely involved. These networks provided for both information exchange and research collaboration. In particular, the Small Ruminant and Camel Group was involved in extensive contacts with national programmes and in the analysis of national data sets that could be used to characterise small ruminant breeds and types.

Table 12. *Effect of phosphorus fertiliser on dry-matter yield of nine* Trifolium *species grown on a Vertisol at Shola, Ethiopian highlands, 1983.*

Species	Days to harvest	DM yield (t/ha) at P rate of (kg P/ha):				
		0	5	10	20	35
Native						
T. quartinianum	135	1.1	3.5	5.7	6.2	6.6
T. tembense	120	1.0	2.1	2.8	4.1	5.4
T. decorum	120	0.7	1.8	3.4	3.8	4.6
T. steudneri	120	0.5	1.9	3.2	3.5	4.3
T. rueppellianum	130	0.5	1.1	2.2	2.7	3.4
T. schimperi	120	1.1	1.5	2.5	2.0	2.8
Exotic						
T. resupinatum	135	0.1	0.4	0.4	0.8	1.0
T. subterraneum	135	0.1	0.4	0.3	0.7	1.5
T. alexandrinum	135	0.1	0.2	0.1	0.3	0.6

Training and information

The Department of Training and Information was created in 1985 with the linking of training, library and documentation and publishing activities under a single director.

Training

Between 1977 and the end of 1984, ILCA gave 11 group training courses, including four on animal nutrition, two on design and analysis of livestock development projects, one on the economics of animal health and disease control, one on forage analysis, one on livestock systems research, one on farm analysis using computers and one on rangeland management. In 1985 alone the Centre offered six courses, including new courses on the standardisation of cattle production data, the handling and dissemination of agricultural information and the use of microcomputers in livestock management and research. In 1986 the number of courses increased further, to eight.

After 1984 the Centre adopted a policy of offering courses in English and French in alternate years.

The second major element of ILCA's training programme was individual trainees, who fell into five categories designed to meet different training needs:

Technician associates: Junior staff from national research institutes who spent 2 to 10 weeks working in ILCA laboratories, research projects

Networking — cooperative research with NARS

ILCA's involvement in networking dates back to 1980, when the African Trypanotolerant Livestock Network was formed. This was followed by the African Research Network on Agricultural Byproducts (ARNAB) in 1981, the Forage Network in Ethiopia (FNE) in 1983, the Small Ruminant and Camel Group network in 1984, and the African Livestock Policy Analysis Network (ALPAN) and the Pasture Network for Eastern and Southern Africa (PANESA), both in 1985.

In 1991, ARNAB and PANESA came together to form the African Feed Resources Network (AFRNET). A Cattle Research Network (CARNET) began in 1989 with the formation of a network for West and central Africa, which was followed in 1990 with an East and Southern African network. The Small Ruminant and Camel Group network became the Small Ruminant Research Network (SRNET) in 1989. These three networks, CARNET, SRNET and AFRNET, have evolved to become strong collaborative research networks.

The networks still in operation in 1994 were CARNET, SRNET, AFRNET, ALPAN and the African Trypanotolerant Livestock Network, operated in collaboration with ILRAD.

The networking concept

ILCA's emphasis on networking was based on a desire to bring together scientists throughout Africa to promote the progress of agricultural research.

ILCA believed that the lack of peer-group contacts among scientists in national programmes in sub-Saharan Africa was leading to duplication of effort and hence waste of resources. The Centre saw networking as a way of overcoming this, and as a way of creating a "critical mass" of scientific expertise that would enable common goals to be achieved faster by focusing effort on mutual problems. The networks were the primary mechanism through which the Centre carried out research in partnership with African institutions.

ILCA saw its roles in networks as being to:

- assist in priority setting and planning their research agenda and working structure
- disseminate research methodologies and new technologies
- provide training opportunities to NARS colleagues
- help set up steering committees
- help organise regular meetings of participating scientists to review research results
- improve information exchange through newsletters, conference proceedings and the publication of research results and
- help attract financial support for the in-country implementation of research projects by national network cells.

The collaborative research networks

The three collaborative research networks — CARNET, SRNET and AFRNET — have similar organisations, with the following characteristics:

- A steering committee of NARS scientists elected by members of the network. The committee defines the research, training and information programmes of the network and, most importantly, evaluates the implementation of the programmes.
- An ILCA staff member is employed as coordinator for each network. The coordinator ensures the rigour of the peer-review process used by the steering committee; convenes steering committee meetings and ensures that committee decisions are acted upon; convenes and organises scientific meetings and edits the proceedings; and produces a network newsletter.
- The network coordinator also acts as a link between the network and ILCA, informing the Centre of training and information needs identified by the network and taking a leading role in ensuring that the Centre responds to those needs.

The key to the success of the networks is in their emphasis on peer-review among NARS scientists, with ILCA playing a facilitating role. The networks "belong" to the NARS, not ILCA.

Projects submitted to the networks for funding undergo a rigorous selection process. All projects submitted are first reviewed at regional planning and review workshops. Those selected by the workshop are then reviewed by the steering committee. Grants are awarded based on the creativity and quality of the science of the proposed projects, their relevance to network priorities, applicability to existing production systems and their potential contribution to sustainable animal agriculture at the national and regional levels.

Grants are made from "in-trust funds" from donors that are held by ILCA on behalf of the NARS. Project implementation is carefully monitored and evaluated by teams of experts, selected from among network members. These teams also provide guidance for the projects where necessary. Results of network research are presented at network workshops, conferences or symposia, with the proceedings providing for wide dissemination of the results.

Achievements

Probably the most important achievement of the networks was in helping develop a confident, self-reliant cadre of scientists in the NARS of sub-Saharan Africa. All the networks have contributed to training scientists and research workers, and in disseminating information. Other specific achievements include:

- AFRNET: distribution of hundreds of forage legume accessions and identification of highly productive forage materials adapted to various ecosystems.
- CARNET: research under this network is expected to result in improved packages that will reduce age at puberty and first calving; reduce calving intervals; increase the efficiency of feed utilisation at the smallholder level; and lead to sustainable increases in milk and meat output in sub-Saharan Africa.
- SRNET: research under way is expected to provide solutions to the key constraints on small ruminant production in the areas of feeds and feeding systems; production and management systems; and breed characterisation and improvement.

or service facilities, learning techniques that would enhance their capabilities.

Undergraduate associates: Young agricultural scientists, mostly from developed countries, working on their first degree, who want to gain experience of working in developing countries. They spent from one to six months working as junior staff in ILCA's field projects. Those from developed countries were externally funded.

Graduate associates: Students working towards an advanced degree who spent from six months to three years at ILCA conducting their thesis research. Visits by their university supervisors also provided an important scientific input into ILCA's research programmes.

Postdoctoral associates: ILCA's programme for postdoctoral associates was established to help African graduates of overseas universities to return to the home continent. It was subsequently extended to graduates of African universities but always concentrated on providing further research experience to early-career African scientists. It was also an important means of increasing the scientific expertise of ILCA's staff.

Visiting scientists: While this category appeared under the heading of "trainees" it was largely ILCA that was the trainee in this category. Visiting scientists offered ILCA the opportunity to gain from the experience of senior African scientists and their knowledge and understanding of the African context.

Training in forage genetic resources work.

The period from 1982 through 1986 saw a large increase in the number of individual trainees working with ILCA. In 1982 there were only 13 individual trainees, two of whom were visiting scientists, while by 1986 there were 60, including four visiting scientists.

This increase in training activities largely reflected the growing maturity of ILCA's research programme and a continuing policy of strengthening ILCA's partners in the national programmes of sub-Saharan Africa.

Information services

The key elements of ILCA's information services were the library, a computerised bibliographic database and the Centre's collection of non-conventional literature held on microfiches.

By 1986, the ILCA library held over 20 000 books and over 1600 periodicals and monograph series. In 1984 the library introduced a 'current contents' service, through which copies of the contents pages of journals received by the ILCA library were distributed to 100 libraries in Africa.

The computerised bibliographic database was a corner-stone of ILCA's information service. By 1986 the database held information on over 45 000 items of conventional and non-conventional literature. Searches of this database were conducted on request for users throughout Africa. The database was also used to develop a number of specialised bibliographies, including *Bibliography on soils, fertilizers, plant nutrition and general agronomy in Ethiopia*, *Beef cattle production from tropical pastures: A descriptive bibliography* and Gliricidia sepium *(Jacq.) Steud: A selected bibliography.*

In 1983 the Centre started a Selective Dissemination of Information (SDI) service covering all aspects of tropical agriculture. The service operated by comparing users' search profiles — lists of key words and other indicators of the research interests of the users — each month with updates of the CAB Abstracts and AGRIS data bases. The computer automatically selected those records that matched the particular user's search profile. A print-out of the resultant search was sent to the user, who could then select those records of particular interest and request photocopies of the documents. By 1986 this service was being used by 555 scientists in 42 African countries.

ILCA's microfiche collection of non-conventional literature is unique. The project to collect this literature from sub-Saharan Africa started in 1978 with funding from the International Development Research Centre (IDRC). IDRC's funding ended in 1986, after which ILCA continued to collect non-conventional literature using core funds. Twenty-three countries in sub-Saharan Africa were covered, and over 18 000 documents were microfiched. The countries covered were: Botswana, Ethiopia, The Gambia, Ghana, Kenya, Malawi, Nigeria, Sudan, Tanzania, Zambia and Zimbabwe in anglophone Africa; and Benin, Burkina Faso, Burundi, Cameroon, Côte d'Ivoire, Mali, Mauritania, Niger, Rwanda, Senegal, Togo and Zaire in francophone Africa. Each institution that participated was provided with a copy of the complete set of microfiches collected from its country, together with a microfiche reader, and copies of the catalogue of microfiches.

Publishing

In 1981 ILCA established an in-house publishing facility capable of taking documents from conceptualisation through finished product. Staff included editor/writers, translators, proofreaders, graphic artists, typesetters and print production staff. This facility was deemed necessary because of the poor quality of printing that could be obtained in Addis Ababa at that time, together with the desire to be independent of outside agencies.

The Publications Section produced a range of publications including an institutional newsletter (first published in 1982), annual reports, research reports, proceedings of conferences and workshops and network publications. The Section also met all the administrative printing needs of the Centre.

Chapter 4

A new focus to ILCA's research

The Second External Programme Review of ILCA, which took place in 1986, commended the Centre's progress but cautioned ILCA to "focus its research activities, ensure continuity of efforts and avoid spreading its resources too thinly over a broad spectrum of activities."

Following the submission of the review report, the Technical Advisory Committee (TAC) of the Consultative Group on International Agricultural Research (CGIAR) asked ILCA to prepare a revised strategy statement to guide the Centre's work through to the end of the century. ILCA started work on this in 1986, continuing through 1987.

After extensive consultation between ILCA's zonal research programmes and their national counterparts, ILCA staff developed a draft strategy paper that was then discussed and revised following a three-day meeting in January that brought together ILCA staff and members of the ILCA Board of Trustees. The revised strategy paper was reviewed by TAC at its meeting in June 1987, and by participants in the Fourth Biennial Meeting of ILCA and Leaders of Livestock Research, Development and Training in Tropical Africa in July 1987. The final document was presented by TAC to the CGIAR at International Centers Week in October 1987, where it received the endorsement of the donors.

ILCA's Strategy and Long-term Plan

Operational goals

All the reviews of ILCA accepted the continuing validity of the Centre's mandate, which was:

> *. . . to assist national efforts which aim to effect a change in the production and marketing systems of tropical Africa so as to increase the sustained yield and output of livestock products and improve the quality of life of the people of this region."*

However, "tropical Africa" is a big place and "livestock products" covers a multitude of possibilities. The continent's livestock sector was, and still is, beset by a complex of technical, social, economic and institutional constraints.

The Strategy identified a number of intermediate or operational goals for ILCA:

- to strengthen the ability of national agricultural research systems (NARS) to conduct technical and policy research in livestock-related fields and thus to develop their own technical solutions to production problems and to promote livestock and rural development.
- to develop, through ILCA's research and that of other organisations, technical packages to increase livestock production and the contribution of livestock to agricultural production and income.
- to contribute to scientific knowledge in a way conducive to solutions to livestock production problems; such knowledge may relate to the understanding of production constraints and opportunities or to research methods and techniques.

Strategy statement

Recognising the Centre's limited financial resources and the number and complexity of factors affecting livestock production in Africa, ILCA's strategy is to choose a limited number of activities that will achieve measurable and sustainable increases in livestock output in sub-Saharan Africa.

Fundamental choices

To complement these operational goals, ILCA made a series of fundamental choices of those species, target groups, zones and commodities on which to focus its efforts. The Centre chose to focus on cattle, sheep and goats; on smallholders and agropastoralists; on the semi-arid, subhumid, humid and highland zones; and on meat, milk, traction and manure.

Project selection

This operational mandate formed the framework within which ILCA operated, but still left considerable room for flexibility in choosing specific projects. ILCA thus developed a number of criteria for use in selecting individual projects. These were:

- Is the problem a researchable one? If so, where does it lie in the research spectrum, and how widely applicable will the research results be?
- In the light of its past experience and current resources, does ILCA have an advantage over other institutes that might work on a given topic?
- Can ILCA find organisations, within or outside the Centre's mandate region, that are both able and willing to work with ILCA so as to increase the scope of the research on a given topic and to broaden its impact?

- Can ILCA command the scientific staff and facilities needed to tackle a given research problem?
- Is the research likely to have a sizeable impact commensurate with one or more of ILCA's operational goals?
- Will the research contribute to an improved production system that is at once sustainable ecologically and stable in terms of economic return?

Six thrusts

The Strategy outlined six "thrusts" or research areas for ILCA to focus on:

- Cattle milk and meat
- Small ruminant meat and milk
- Animal traction
- Animal feed resources
- Trypanotolerance
- Livestock policy and resource use.

The first three were "commodity thrusts", in that they aimed at increasing the output of the three products, milk, meat and traction. The other three were "strategic thrusts", supporting the commodity thrusts by providing inputs of information and technology.

Cattle milk and meat

ILCA's research under this thrust concentrated on the subhumid, humid and highland zones of Africa. The Strategy identified major opportunities for large increases in production of milk and meat from cattle in each of these zones. The subhumid zone was seen as offering the best possibilities for increases in the short to medium term because it had reasonable potential for feed production, low trypanosomiasis risk, relatively sparse human population and a relatively large cattle population. The potential for increased cattle production in the humid zone was seen as vast but unlikely to be realised immediately. The main constraint was seen as being diseases, primarily trypanosomiasis and dermatophilosis. The opportunities for increasing meat production in the highlands of East Africa were seen as limited, because these areas were already well supplied with meat, but opportunities were identified for increasing milk production if forages could be incorporated into cropping patterns.

The major topics identified under this thrust were:

- evaluation of the genetic potential of cattle breeds and their crosses for milk and meat production

- use of forage legumes to support both crop production and a dairy enterprise
- development of feeding systems for dairy cows and fattening cattle
- reduction of reproductive wastage and young-stock losses
- development of simple milk-processing techniques to increase the marketability of dairy products
- use of trypanotolerant stock to launch pilot smallholder milk-production projects in the humid zone
- identification of policy and institutional factors determining successful smallholder milk and meat production and marketing
- investigation of social and economic obstacles to increased milk production and consumption.

Small ruminant meat and milk

Meat and milk from small ruminants are important both for subsistence and as potential sources of additional income for resource-poor smallholders in sub-Saharan Africa. The small body size, high reproductive rate and rapid growth of sheep and goats make it easy to integrate these animals into production systems. The Strategy identified three major zones on which ILCA would focus its research: the semi-arid zone, where most small ruminants were raised and where there was a large potential for exporting live animals to other zones; the highlands, which offered considerable scope for producing and marketing sheep; and the humid zone, which had both markets and high potential for forage production.

The major projects that were to be addressed by the thrust were:

- evaluation of small ruminant genetic resources in order to identify appropriate breeding strategies
- identification and testing of suitable browse and forage legumes for smallholder production systems
- use of improved management and feeding practices to reduce disease risk and increase productivity
- investigation of the extent and causes of reproductive wastage and testing of possible solutions
- determination of the impact of improved production systems on farm income and producer welfare
- analysis of social and economic factors affecting technology uptake.

Animal traction

Although it was estimated that animal traction accounted for nearly one third of the total value of livestock outputs in sub-Saharan Africa, only 10 to 15% of Africa's farmers were thought to be using animal traction in the mid-1980s. Most draft animals were in the semi-arid and highland zones, where they were used primarily for ploughing and threshing but little else.

Previous attempts to introduce the use of animal traction gave poor results, mainly due to lack of inputs, inappropriate technologies and inadequate nutrition of the draft animals. If the use of draft animals is to persist once introduced, the Strategy argued, a number of conditions must be met. First, investment costs for both animals and implements must be low. Second, there must be opportunities for intensifying and diversifying the applications of animal traction. Third, farmers will have to learn animal-management skills in addition to cultivation techniques, and extension staff will have to be trained in the use of animal traction if they are to provide useful advice. Fourth, the problem of animal nutrition will have to be addressed through low-cost inputs to increase the efficiency of draft animals, and appropriate animal health packages will be needed to protect them against disease.

The research under this theme fell into two main categories:

- intensifying and diversifying the use of animal traction in the highland and semi-arid zones
- examining the constraints to the adoption of animal traction in those zones where it was not currently used, primarily the subhumid zone, and the introduction of packages that combine all the inputs needed to overcome the constraints identified.

The major topics to be addressed were:

- adaptation and testing of low-cost implements to improve farm operations and improve soil and water management
- assessment of working efficiency at low levels of feeding, and testing of strategic supplementary feeding
- determination of the impact of improved animal traction technology on food production and farm income
- development of efficient triple-purpose (draft, milk and meat) animal-production enterprises
- integration of crop and livestock production through improved use of manure
- diagnosis of technical, social and economic constraints to the use of draft animals in the subhumid zone
- creation of complete packages (including credit, veterinary services etc) for introducing animal traction to new areas.

Animal feed resources

Feed shortage in the dry season, and even in the wet season, is a major constraint to animal production in all zones except the humid zone. Even where feed is plentiful, it may not provide a balanced diet, or may be inefficiently converted into animal products. To increase the availability and quality of feed, packages are needed that combine a variety of feed resources, including forage legumes, fodder trees, crop residues and agro-industrial by-products, as well as other existing feed resources. The aim of the Animal Feed Resources Thrust was to develop and evaluate suitable forages and other feeds, and to increase the efficiency with which feed resources are utilised.

Priority activities for this thrust were identified as being:

- acquisition, storage, screening and evaluation of forage germplasm of potential value to smallholder production systems
- identification of entry points for forage legumes and multipurpose trees in traditional farming systems
- investigation of soil–plant–water–nutrient relationships in order to increase forage and food crop yields
- determination of the response of legumes to rock phosphate or other low-cost fertilisers
- determination and improvement of the nutritive value of new and existing feed resources in order to develop improved feed packages
- investigation of the ability of selected feed combinations to increase animal production through improved rumen function and feed conversion
- development of grain crop varieties with increased feed value of the residue as well as higher grain yield
- investigation of economic and institutional factors inhibiting the optimum use of feed resources.

Trypanotolerance

Trypanosomiasis, transmitted by the tsetse fly, inhibits animal production in an area of humid and subhumid Africa larger than the USA. Small populations of cattle, sheep and goats tolerant of the disease are found in this area. If these trypanotolerant animals are to play their part in meeting West and central Africa's large and growing demand for meat and milk, more needed to be known about the conditions determining their successful use. Information was needed on genetic and acquired resistance, environmental factors affecting susceptibility and the efficacy of control measures, as well as further studies on the productivity of the trypanotolerant breeds themselves.

Research under this thrust concentrated in the humid and subhumid zones and continued to address the following topics:

- collection and analysis of data on the productivity of trypanotolerant breeds under varying levels of trypanosomiasis risk
- identification of more reliable indicators of trypanosomiasis risk
- definition of a selection criterion for trypanotolerance in order to devise optimum breeding programmes
- evaluation of the costs and benefits of selected tsetse control measures and their interaction with prophylactic drugs
- testing of nutritional interventions to improve livestock productivity in tsetse-infested areas
- studying the effects of trypanocidal drugs in order to determine appropriate interventions in areas of medium to high trypanosomiasis risk.

Livestock policy and resource use

At the time ILCA was developing its Strategy and Long-term Plan it was already acknowledged that better policies and resource management were crucial to livestock development in Africa. Policy problems were ubiquitous and broadly similar in kind throughout the continent. However, it was recognised that there was a need to compare the experiences in different countries in their search for solutions, since these were expected to vary according to the natural and socio-economic environments. Problems in resource use, on the other hand, are at their most acute in the semi-arid and arid lands, where the long-term future of agriculture appears to be threatened. Here there is a need to develop better methods to assess both resources and long-term productivity trends, and to improve the role of livestock in stabilising and sustaining farm income and crop production in marginal areas. Thus, work that had been suspended following the comments of the first Quinquennial Review was to be revived under the "new" concept of environmental sustainability.

Research activities in this thrust thus concentrated on cross-country comparison of the critical policy issues affecting technology uptake, and on the sustainability of crop and livestock production, especially in marginal areas. The major topics covered included:

- ways in which government policies influence the use of inputs and the adoption of technology by producers
- the effects of government policies on the stability and sustainability of mixed farming in marginal areas
- the role of livestock in stabilising and sustaining farming systems in the semi-arid zone

- development of low-cost methods to assess long-term productivity trends in the semi-arid and arid rangelands
- the role of credit in technology adoption by livestock producers
- relationships between land tenure and other factors affecting technology adoption
- social and economic factors affecting the demand for livestock products
- financing of livestock services
- the effects of meat and milk pricing policies on production by smallholders and pastoralists.

Training and Information

The four major concepts that governed ILCA's training and information activities in the Strategy and Long-term Plan were that:

- they should be based on needs expressed by NARS
- in most cases they should be closely related to ILCA's thrusts
- ILCA had a role to fulfil in bringing skills and information to Africa from other parts of the world
- there must be a two-way flow of information between ILCA and NARS.

Training

The focus of ILCA's Strategy was on collaborative research and networking. Initially, it was decided, training would concentrate on training young African scientists in research techniques to ensure that there were effective partners in the research effort.

The Strategy envisaged that, as ILCA's research programme generated more technology, the emphasis would shift towards training technicians in adapting and transferring technologies. It was hoped that this would be achieved primarily through "training the trainers."

While the Strategy clearly linked most training to ILCA's research thrusts, it included scope for ILCA, in collaboration with other institutes, to offer courses on some additional subjects that were believed to be vital to the development of livestock production in Africa.

Documentation

The Strategy noted that many African NARS lacked adequate access to information on livestock production. ILCA already provided a comprehensive range of information services to African users, including selective dissemination of information, current titles and the provision of microfiches and photocopies. The Strategy provided for these services to be continued, and expanded, as resources allowed. Again, the focus was to be support for the ILCA research programme, with emphasis on provision of information related to the Centre's research thrusts.

Modes of operation

Research planning

The major research topics outlined in the Strategy document were identified through a process of consultation with NARS, including:

- regional contacts maintained by ILCA's zonal research teams
- contacts with NARS scientists and trainees visiting ILCA's headquarters
- meetings with network participants and prospective participants
- visits to African universities
- advice from NARS representatives on ILCA's Board of Trustees
- research priorities previously identified by NARS at conferences and workshops
- priorities expressed at the 1984 Biennial Meeting between ILCA and Leaders of Livestock Research, Development and Training in Africa.

The Strategy envisaged that the thrusts identified would initially run for a five-year period, and allowed for planning meetings to which ILCA would invite NARS scientists and other specialists. These meetings were intended to develop the detailed five-year work plans for the thrusts.

These meetings were to be supplemented by the continuing Biennial Meetings between ILCA and Leaders of Livestock Research, Development and Training in Africa, at which the Centre's NARS partners were to be asked to help ILCA set guidelines on research priorities, assess past progress and identify new opportunities.

Research implementation

The Strategy identified three categories of research arrangements: collaborative research with NARS, contract research with specialised institutes and ILCA's own research.

Collaborative research was seen as a means of increasing the effectiveness of ILCA's research by linking the Centre to NARS. Much of this work was to be conducted through collaborative research networks, some of which were already being coordinated by the Centre. Contract research was seen as a way of addressing specific strategic issues that ILCA lacked the expertise to tackle. Research was to be undertaken by ILCA itself when NARS did not have the necessary resources to participate in the research or where necessary strategic research was within the capacities and facilities of ILCA working alone.

The Strategy also reiterated ILCA's commitment to the farming systems approach to research and ensuring a mix of disciplines in its research teams.

From Strategy to Medium-term Plan

Six thrust planning meetings were held during the second half of 1987 to flesh out the research programme outlined in the Strategy and Long-term Plan. Each of these meetings was attended by scientists from ILCA, from African national and regional institutions and from institutions from outside Africa. The participants were drawn from a range of disciplines to ensure comprehensive coverage of all the problems to be dealt with by the multidisciplinary thrusts. The meetings used a "goal-oriented project planning" method to ensure consistent, logical and rational consideration of the opportunities presented by each thrust.

During the initial analysis phase of each planning meeting, participants first identified the principal problems limiting livestock production that fell within the scope of the thrust under consideration. They then listed causes and effects of these constraints. The main cause-effect relationships characterising the major problems were then depicted as a "problem tree", which was then transformed into a "hierarchy of objectives" or a "goal tree".

This information was used to draw up a "project planning matrix" for each thrust. This showed the thrust's overall goal and expected outputs and the major activities needed to achieve those outputs. Table 13 shows the project planning matrix for the Cattle Milk and Meat Thrust.

Having identified a number of activities for each thrust, the participants presented ideas for themes incorporating activities with a common objective. The proposed themes were subsequently examined in terms of the research priorities outlined in the project planning matrices and refined to match ILCA's expected resources. In some cases, activities were aggregated to avoid fragmentation of work.

Outlines of possible project protocols were also prepared during the meetings. The proposed protocols were screened against the criteria for project selection specified in the Strategy.

By bringing together people from different disciplines, and by employing a logical structure for discussion, the planning meetings provided a means for a comprehensive assessment of the problems and opportunities presented by each thrust. They facilitated a synthesis of the views of ILCA researchers with those of African NARS scientists and others working outside the continent.

A similar planning meeting was held in 1989 to develop the training and information programme for the Centre.

Following the planning meetings, the thrust coordinators — senior ILCA scientists given the task of coordinating the diverse research

Table 13. *Project planning matrix for the Cattle Milk and Meat Thrust.*

GOAL: Increased milk and meat production							
PURPOSE: Develop solutions to constraints in milk and meat production							
OUTPUTS/ RESULTS	1. Solutions to reduce calf mortality identified	2. Solutions to reduce calving intervals	3. Feeding strategy and appropriate management systems for smallholder milk and meat production developed	4. Milk utilisation techniques developed	5. Solutions to reduce infectious parasitic diseases developed	6. Socio-economic obstacles to increased milk production and consumption identified	7. Genetic potential of cattle for milk and meat production evaluated
ACTIVITY	1.1 Identify potential causes; develop prevention and treatment	2.1 Develop methods to improve heat detection	3.1 Identify recommendation domains	4.1 Identify system constraints	5.1 Develop procedures for improved disease resistance	6.1 Identify appropriate milk marketing policies	7.1 Analyse current situation
	1.2 Develop appropriate shelter/housing	2.2 Develop methods to reduce reproductive disorders	3.2 Study system constraints	4.2 Develop equipment packages	5.2 Develop methods to reduce exposure to pathogens	6.2 Identify appropriate credit policies for milk production	7.2 Identify appropriate genotypes
	1.3 Develop supplementary feeding based on local raw materials	2.3 Develop appropriate strategies for improved cow nutrition	3.3 Identify feeding/ management packages	4.3 Develop technology packages	5.3 Develop procedures to improve treatment of infected animals	6.3 Make recommendations for viable production systems	7.3 Assess improvement of genetic potential
	1.4 Develop supplementary feeding strategies for dams before and after calving	2.4 Develop early weaning programmes		4.4 Study alternative products	5.4 Examine cost-benefit relationships in veterinary services		7.4 Identify methods for the distribution improved
	1.5 Develop appropriate pre- and post-calving dam/calf husbandry strategies	2.5 Improve male reproductive efficiency		4.5 Carry out cost-benefit analysis			7.5 Analyse technical and socio-economic consequences
	1.6 Examine cost-benefit relationships in calf rearing	2.6 Examine cost-benefit relationships in shortening calving intervals					

activities of the thrusts — and the Director of Research finalised the research programme for 1988 and planned the development of the themes within thrusts for each year up to 1993. They were guided in this by the thrust planning matrices developed in the thrust planning meetings, and by the comments and advice of ILCA's Board of Trustees.

ILCA's medium-term plan for 1989 to 1993 was published as *Sustainable production from livestock in sub-Saharan Africa: ILCA's programme plans and funding requirements 1989–1993.*

ILCA's programme, 1987–93

Although ILCA did not formally adopt the thrust-based research concept until 1988, the *ILCA Annual Report 1987* and subsequent annual reports all reported along thrust lines rather than the previous disciplinary units and zonal teams. This chapter will follow the same principle.

Cattle Milk and Meat Thrust

The Cattle Milk and Meat Thrust had five research themes:

- Reproductive wastage and hygiene management
- Feeding and management systems
- Milk preservation and processing
- Economics of cattle production
- Breed evaluation and improvement.

Reproductive wastage and hygiene management

Poor reproductive performance of zebu cattle had been identified as one of the main constraints on cattle production in sub-Saharan Africa. This poor performance had been primarily attributed to (1) late puberty and sexual maturity in males and females and, therefore, late age at first calving, (2) long post-partum anoestrus periods resulting in long calving intervals and (3) overall low fertility rates.

Research under this theme was largely directed towards quantifying the effect of strategic nutritional supplementation on growth and reproductive performance of young animals and the post-partum cow. As part of an evaluation of specific reproductive physiology patterns in zebus, studies were made to characterise the oestrous cycle of the East African Zebu, pubertal development of growing heifers and bulls, reproductive capacity of mature bulls, and the influence of nutritional supplementation and suckling intensity on the post-partum reproductive performance of zebu cows.

Calf-rearing strategies

ILCA undertook studies of calf-rearing strategies in several environments, including the Ethiopian highlands (see *"Calf rearing,"* pages 103–105, Chapter 4) and the southern rangelands of Ethiopia (see also *"Animal production,"* pages 64–65, Chapter 3).

A long-term trial in the Ethiopian rangelands showed that giving calves extra feed and water to increase their early growth was not worthwhile. While animals receiving the best combination of supplementary feeding and extra water were 45% heavier at one year old than those in the unsupplemented control group, they were only 4% heavier at three years old (196 vs 188 kg; Figure 18). There was a similar convergence in weight between animals that received all their mothers' milk and the control animals, which received only half.

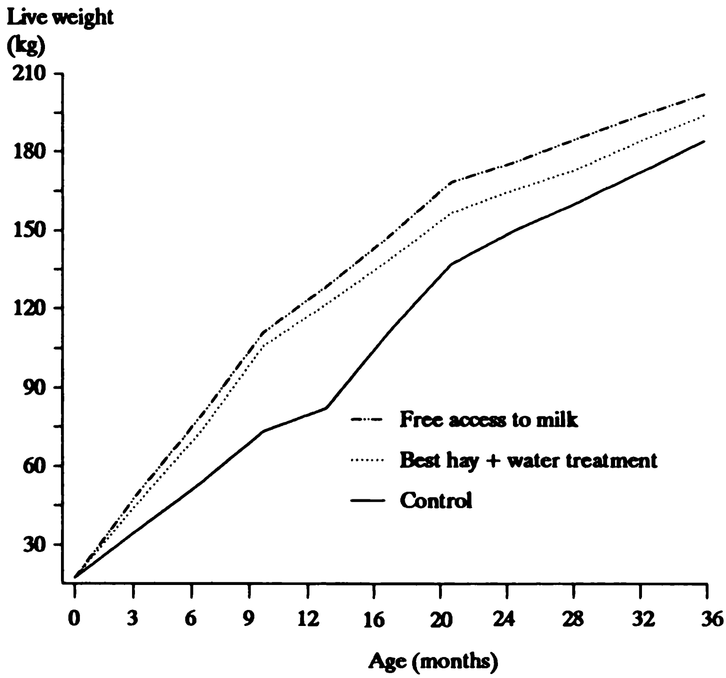


Figure 18. *Growth to three years of cattle on semi-arid rangeland in southern Ethiopia following various preweaning treatments from two to nine months of age.*

Animals in the best supplementation treatment group reached puberty an average of 177 days earlier than animals in the control group. However, cows in this production system commonly calve until they are 12 years old or more. Hence this reduction in time to puberty may not be of marked importance, especially in a subsistence-oriented system where milk production is a primary goal.

In contrast, a trial with Arsi x Friesian crossbred calves showed that early weaning combined with supplementary feeding resulted in increased weaning weights but that this weight advantage was maintained after weaning. Supplementation consisted of 1 kg/head daily of a supplement composed of 50.5% wheat bran, 48.0% noug (*Guizotia abyssinica*) cake, 1.0% limestone and 0.5% common salt.

Mortality during the four months after weaning was significantly higher among control calves weaned at eight months old than among early-weaned calves (30% vs 10%; P<0.01). Economic analysis showed that the cost of supplementation was considerably less than the value of the extra live weight and increased survival of the supplemented calves. In addition, 37% (n=22) of the dams of early-weaned calves returned to oestrus within eight months of the birth of their calves (Table 14).

Table 14. *Effect of calf weaning age on resumption of oestrus activity in dams.*

Group	Number of cows	Age of calves at weaning (months)	Number of cows cycling by calf age (months)					
			6	7	8	9	10	11
I	20	5	5	6	7	8	9	10
II	22	6	5	9	9	11	11	
III	18	7	6	7	7	7		
Control	18	8/9	6	6	6			

Feeding and management systems

Smallholder dairying in coastal Kenya

In 1989, ILCA and the Kenya Agricultural Research Institute (KARI) established a joint project at the Kenya coast focusing on smallholder dairying in the coastal subhumid zone. A major component of this project addressed feeding and management systems.

The smallholder dairying system being promoted at the Kenya coast used crossbred dairy cows fed a basal diet of Napier grass (*Pennisetum purpureum*) supplemented with bought-in protein sources such as copra cake. The ILCA/KARI programme investigated ways for farmers to produce all the feed they needed on their farms, making the system self-sustaining and more robust. The programme explored two possibilities: interplanting Napier with herbaceous forage legumes, and alley farming — growing Napier and food crops in "alleys" between hedgerows of the leguminous browse tree, *Leucaena leucocephala*.

Interplanting Napier with *Clitoria ternatea*, a climbing, herbaceous forage legume, produced total yields of up to 26 tonnes of dry matter per hectare, 5.6 tonnes of which was *Clitoria*. This is enough to feed five dairy cattle for a whole year. Napier grown alone yielded about 20 tonnes of dry matter per hectare. Including *Clitoria* thus increased both the amount of feed available and its quality.

Feeding trials showed that cows fed Napier grass harvested when 1.0 metre tall gave significantly higher milk yields (8.5 vs 6.8 kg per day) and lost significantly less weight (10 vs 45 kg over the 98-day trial) than those fed Napier cut at 1.5 metres tall. Harvesting Napier at 1.0 metre tall instead of at 1.5 metres tall only slightly reduced annual yields, from 16.7 to 15.7 tonnes of dry matter per hectare.

Supplementation trials showed that *Leucaena* foliage was an effective supplement to a Napier-based diet, significantly increasing milk yield, especially when fed in combination with maize bran.

A simulation model of feed availability and dairy output from feeds showed that a typical three-hectare farm with two hectares of natural pasture and 0.3 ha of Napier grass should provide enough dry matter, metabolisable energy and crude protein to sustain the then-current levels of milk production (1850 kg in a 402-day lactation), except in the long dry season in years of poor rainfall. With the prevailing land allocation, nutrient density in the forage was too low to allow milk production to increase to the levels achieved by medium- to large-scale farmers with similar cows (3080 kg in 321 days). Including *Leucaena*, for crude protein, and cassava, for energy, in the cropping system would raise the nutrient density of the diet available and increase the milk yield that could be achieved while reducing variability between years.

Calf rearing

As part of its work on smallholder dairying, ILCA conducted a number of studies on calf rearing strategies aimed at increasing overall productivity. An example of this is research on the management of zebu x Friesian crossbred cows, which have been widely distributed in Ethiopia as part of a World-Bank-supported dairy development initiative (see also *"Increasing milk production,"* pages 45–48, Chapter 3).

Although it is generally recognised that the calf must be present to stimulate milk letdown in zebu cows, it was not thought that this was necessary with crossbred cows. Under Ethiopian Ministry of Agriculture (MoA) recommendations, calves were not suckled except for the first four days after they are born but were reared by bucket feeding a total of about 200 kg of milk up to weaning at 84 days old.

In the ILCA trial, calves were either fed according to MoA recommendations or were allowed to suckle before and after the morning and evening milking, for two minutes before the cow was milked and again for 30 minutes after milking. Cows each received a basal diet of *ad libitum* teff (*Eragrostis tef*) straw plus 2 kg of noug cake daily. Supplemented cows received an additional daily ration of 2 kg of legume hay throughout their lactations. Calves were weighed weekly until 180 days old. Results are shown in Table 15.

Partial suckling in early lactation significantly increased milk yield between the fourth and 84th day of lactation. The difference in saleable milk production over that period was not significant.

Table 15. *The effect of calf-feeding system, dam supplementation and dam breed on milk yield, calf milk consumption, calf growth and digestible dry-matter intake, Debre Zeit, Ethiopia, 1989.*

	Milk yield (kg/cow per day)		Saleable milk (kg/cow per day)	Calf milk intake (kg/calf per day)	Calf growth rate (g/day)		Digestible dry-matter intake (kg/cow per day)	
	4–84 days	4–305 days	4–84 days	0–84 days	0–84 days	0–180 days	4–84 days	4–305 days
Calf feeding								
Bucket-fed	5.4	4.5	2.7	2.7	304	268	4.3	4.2
Partially suckled	6.2	4.8	3.1	3.1	390	323	4.5	4.3
Cow feeding								
Non-supplemented	5.7	4.4	2.9	2.8	323	282	4.1	3.9
Supplemented	5.9	4.9	2.9	3.0	371	309	4.7	4.5
Dam breed								
Friesian x Arsi	5.5	4.4	2.6	2.9	348	285	4.4	4.2
Friesian x Boran	6.1	4.9	3.2	2.9	345	306	4.4	4.3
SE	0.12	0.16	0.19	0.07	16.0	13.0	0.07	0.07

Milking a crossbred cow in the Ethiopian highlands. ILCA studies showed that allowing calves to suckle before and after milking increased both milk yield and calf growth.

Partially suckled calves had significantly higher daily growth rates to weaning at 84 days and to six months old than did bucket-fed calves. This was associated with significantly higher milk intake by partially suckled calves.

Supplementary feeding significantly increased digestible dry-matter intake by cows over both 4–84 days and 4–305 days. Calves of supplemented cows had significantly higher growth rates to weaning than did calves of unsupplemented cows.

Friesian x Boran cows gave significantly higher milk yields up to the 84th day of lactation than did Friesian x Arsi cows. Calf milk intake was similar, and hence Friesian x Boran cows produced significantly more saleable milk than did Friesian x Arsi cows.

Partial suckling tended to increase the interval from calving to conception, but the difference was not significant.

This study thus showed that allowing calves to suckle before and after hand milking increased milk yield in these crossbred cows. Partial suckling also increased calf growth rates to weaning without reducing the amount of milk available for sale.

Other studies showed that partially suckled calves and bucket-fed calves had similar growth rates after weaning. Thus, the 20 kg weight advantage that the partially suckled calves had at weaning would be maintained, leading to earlier puberty in the partially suckled calves.

Milk preservation and processing

ILCA's studies on milk preservation and processing techniques have focused on characterising the techniques used by smallholders, examining market opportunities and developing products and processing techniques to take advantage of these opportunities. Much of the effort has been directed at improving on what farmers are doing already, rather than introducing new concepts.

From early studies in the Ethiopian highlands, it was apparent that the traditional clay-pot churn was an inefficient tool for making butter and efforts were directed at increasing its efficiency (see *"Increasing milk production,* pages 45–48, Chapter 3).

ILCA developed a simple wooden paddle wheel that could fit in the traditional churn and provide the agitation needed to produce butter.

The agitator was tested in a series of trials over several years. Trials in 1989, for example, monitored the use of the agitator on five farms near Debre Birhan, in the Ethiopian highlands. The farmers used their usual manufacturing procedure, i.e. the same churning temperature and amount and acidity of milk, except their clay pots were fitted with the agitator.

Churning time ranged from 50 to 65 minutes, with an average of about 57 minutes, compared with an average of 139 minutes observed in a previous study of the use of the unmodified churn. The average fat content of the buttermilk was also much lower from the agitator than from the traditional churn (0.36% vs 1.1%).

A trial in 1990 showed similar results, the agitator increasing average fat recovery from 65.1% for the traditional churn to 80.2% for the agitator. This increase in fat recovery is of considerable economic importance, since the price of butter was about seven times that of the cheese made from buttermilk.

Other work included:

- a study, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), of improved techniques for producing scamorzza cheese;
- investigations of various ways of preserving milk and milk products, including:
    - using thiocyanate to preserve fresh milk
    - the effect of pressing and salting on the shelf-life of cottage cheese
    - the effect of salt and temperature on the shelf-life of butter
    - the effect of spices on chemical and microbiological quality of butter
    - identifying local sources of milk coagulating agents for use in smallholder cheesemaking.

Economics of cattle production

Key elements of ILCA's work on the economics of cattle production included studies on patterns of consumption of dairy products in West Africa, an examination of socio-economic obstacles to increased

Studying traditional milk processing techniques in the southern Ethiopian rangelands.

production and consumption of milk in Bamako, Mali, and a study of milk marketing and consumption in Nigeria (see also *"Imports of dairy products,"* pages 78–79, Chapter 3).

Work under this theme culminated in 1990 in ILCA convening an international symposium on dairy marketing in sub-Saharan Africa, the proceedings of which were published under the title of *Dairy marketing in sub-Saharan Africa.*

Dairy-product consumption in West Africa

In a major study of dairy-product consumption and production in West Africa, data from FAO indicated that annual consumption of milk and milk products in West Africa increased from 15 kg per person in 1974–76 to 18 kg per person on 1983–85 but fell to only 12 kg per person in 1985–87. Milk production increased only slowly during the 1970s and 1980s, even declining in drier parts of the region. In contrast, imports increased rapidly during the 1970s but subsequently declined, their share of total consumption falling from 45% in 1983–85 to 36% in 1985–87.

A study was carried out in 1989 to determine the pattern and distribution of dairy consumption in West Africa in 1985–87 and trace some of the more obvious factors that led to the consumption situation.

Aggregate dairy demand in West Africa for 1985–87 was estimated from FAO milk production and import data. This was then disaggregated by product type and origin (local or imported), by ecological zone (dry or humid) and by rural and urban areas.

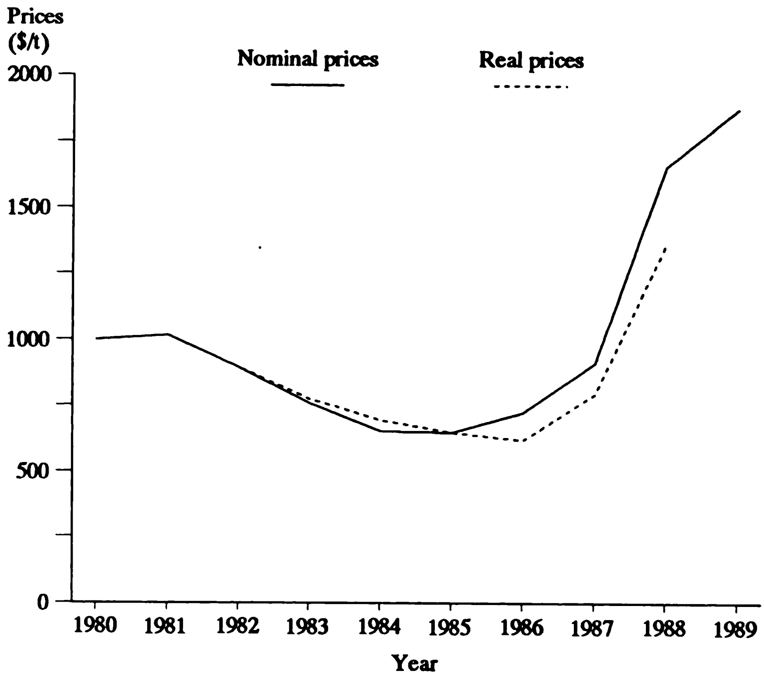
In the 16 countries of West Africa, consumption of milk and milk products averaged 2.6 million tonnes (liquid-milk equivalent) annually in 1985–87. This was roughly 0.5 million tonnes a year less than in 1983–85. Per caput dairy consumption fell from 11 kg in 1983–85 to about 6 kg in 1985–87 in the humid zone and from 45 kg to 41 kg in the dry zone. This large fall in per caput consumption in the humid zone was reflected in a fall in the proportion of consumption accounted for by that zone, from 49% in 1983–85 to about 40% in 1985–87.

In 1985–87, local products accounted for about 71% of consumption in the dry zone, compared with only 54% in the humid zone. The equivalent figures for 1983–85 were 72% in the dry zone and 38% in the humid zone, the figure for the humid zone reflecting the decline in imports between 1983–85 and 1985–87.

In the dry zone, the proportion of consumption accounted for by urban dwellers increased slightly, from 21% in 1983–85 to 23% in 1985–87, whereas in the humid zone it fell from 62% to 46%.

Dairy consumption in West Africa was thus falling in the late 1980s, especially in the humid zone, which depended heavily on imported dairy products. At that time it was felt that imports would likely continue to decline as their costs were expected to continue to increase (Figure 19) and income growth was expected to slow.

Figure 19. *Nominal and real prices of non-fat dry milk on international markets, 1980–89.*



The study suggested that there were considerable opportunities for promoting milk production in West Africa to meet demand that was no longer being met by imported products.

Milk production and consumption in Mali

A related study examined differences between income groups in consumption of the various dairy products available in Bamako, Mali, to determine the relationships between dairy consumption, income and prices, as well as the influence of season and socio-economic and demographic parameters on dairy consumption.

Household income averaged 85 000 CFA francs/month ($284) (Table 16), with a range from 4500 CFA francs/month ($15) to 700 000 CFA francs/month ($2333). The poorest 10% of the households had 1% of the total income, while the richest 10% received 36%. Although the sample was initially post-classified into five homogeneous income categories, it was later reclassified into three income categories: the poorest 25% of households, the middle 50%, and the richest 25%. Poor households had monthly incomes of between 4500 and 30 000 CFA francs ($15–100) and middle-income households had incomes of between 30 000 and 100 000 CFA francs/month ($100–333). Rich households had monthly incomes of more than 100 000 CFA francs per month.

Table 16. *Household dairy consumption patterns by income, Bamako, Mali, 1988/89.*

	Income category			
	Whole sample	Poorest 25%	Middle 50%	Richest 25%
Number of households	237	54	120	63
Average household income (CFA francs/month)	85 370	19 472	61 722	185 309
Dairy consumption pattern (% of households)				
Regularly consume dairy products	75	51	79	92
Rarely or never consume dairy products	25	49	21	8
Consumption				
kg LME/per person per year	12	6.4	11.8	22
Local products (%)	34	37	33	60
Factory products (%)	12	29	19	15
Imported products (%)	54	34	48	25
Dairy expenditures				
% of household budget	2.6	3.4	2.5	1.8

The average household comprised 10.6 people, half of whom were less than 16 years old. Poor households were smaller than middle-income households and rich households, yet spent a larger proportion of their monthly income on dairy products. They also has a larger proportion of members who were uneducated or involved in manual labour than did rich households. Only 4% of people in the sample had six or more years of formal education; 32% had none. Nearly half of the workers in the sample were employed by the government.

Thirty per cent or more of the households consumed locally produced fresh and sour milk, factory-reconstituted liquid milk, imported concentrated milk and milk powder at least once a week. Locally made sweetened sour milk, local butter, factory-produced butter and cheese and imported fresh UHT (ultra-heat treated) milk, yoghurt, cheese and butter were consumed very irregularly. Shortage of money was cited as the major reason limiting consumption, particularly by poor households in respect of imported and factory-produced products. Other reasons cited included dislike of dairy products, non-availability of some products, or lack of awareness of what products were available.

Sample households consumed an average of 12 kg of liquid milk equivalent (LME) per person per year, consumption ranging from 6.4 kg in poor households to 22 kg in rich households (Table 16). The type of product consumed showed a strong preference for local products. Fresh and sour milk together accounted for 96% of total local dairy product consumption.

The amount of imported dairy products consumed did not differ significantly between seasons, but consumption of local products was markedly higher during the rainy season than in the hot dry or cool dry seasons. In the hot dry season, for example, only 60% as much local dairy product was consumed as during the rainy season. Socio-economic parameters did not significantly affect demand for dairy products, which was generally income inelastic, with coefficients ranging from 0.14 for factory-pasteurised milk to 0.49 for imported concentrated milk. Demand for factory-reconstituted and imported concentrated milk was price elastic (-1.62 and -1.50, respectively), while demand for local fresh milk was price inelastic (-0.53). The cross-price effects show mixed results, but in general local fresh milk had positive cross-price coefficients with imported dairy products (substitutes) and negative coefficients with local sour milk (complements).

The income and price elasticities for each income group were used to assess the implications of the Malian Government's goal of increasing annual dairy consumption to 40 kg LME per person by the year 2000. To achieve this, dairy consumption would have had to increase by 13% a year for the sample as a whole, by 23% a year for poor households and by 6% a year for rich households. This would have required substantial reductions in dairy-product prices or large increases in incomes, or both.

Increasing local milk production by introducing low-cost production techniques, efficient feeding systems, improved health programmes and efficient marketing systems was identified as a possible sustainable route to increasing dairy consumption.

Consumption studies

In 1989–90 ILCA also carried out milk consumption studies in the humid and subhumid zones of Nigeria. These showed that, overall, between two-thirds and four-fifths of households regularly consumed milk or milk products. The highest consumption — 47 kg per person per year — was found in the subhumid zone, reflecting the large proportion of Fulani pastoralists in the area. The Fulani traditionally depend primarily on their livestock for subsistence and hence consume large amounts of milk and milk products.

The proportion of local products consumed ranged from negligible in the humid zone, where the local population has no tradition of keeping cattle, to nearly 80% in the subhumid zone.

Marketing and policy studies

Other important studies relating to the economics of cattle production include marketing studies in Mali, Nigeria and Ethiopia (results of the latter were published as ILCA Research Report 19, *Dairy marketing in Ethiopia: Markets of first sale and producers' marketing patterns* (see also Chapter 3, "*Dairy marketing systems,*" pages 79–80); a study of the effects of dairy imports on consumption and production in sub-Saharan Africa, published as ILCA Research Report 17, *Dairy imports into sub-Saharan Africa: Problems, policies and prospects*; and a study of the effects of pricing policies on meat and milk production, published as ILCA Research Report 20, *Impact of livestock pricing policies on meat and milk output in selected sub-Saharan African countries.*

The marketing studies confirmed that, given the practical difficulties and high costs of collecting and transporting milk produced in rural areas, peri-urban producers are best placed to produce milk profitably and at a price urban consumers can afford. This led to ILCA's subsequent emphasis on peri-urban dairying.

Breed evaluation and improvement

Over the years, ILCA helped analyse and publish data sets characterising various cattle populations and herds (see also Chapter 3, "*Livestock productivity studies,*" pages 75–76). In 1989 and 1990, for example, assistance was provided to NARS in Ethiopia, Ghana, Kenya, Malawi, Swaziland and Zimbabwe in analysis and interpretation of breeding data.

Studies in Kenya

During 1991, ILCA scientists helped analyse performance data collected at the National Sahiwal Stud, Naivasha, Kenya, between 1963 and 1988, bringing to light some important information on the performance of the breeding programme.

The Stud had operated a "closed-herd" breed improvement system since the early 1960s. The principal aims of the Stud are to produce improved dual-purpose (meat and milk) Sahiwal cattle for use by smallholder farmers in Kenya by selecting within the breed. As is so often the case, however, data collected over several years had not been analysed, leaving research staff at the Stud unaware of what changes were being effected in the Sahiwal population at the Stud.

The results of the analyses showed that the genetic progress that the Sahiwal breed improvement programme was making was unacceptably low. Genetically, milk yield was increasing by 4.2 kg a year and calving interval was decreasing by 0.31 days a year, while changes in birth weight and age at 55 kg live weight were negligible. Of more concern, actual milk yields fell by 12.7 kg a year and calving interval lengthened by 2.72 days a year. These phenotypic changes, the result of a combination of the animal's genetic potential and the effect of its environment, reflected a deterioration in management of the animals in the later part of the period covered by the data. The study also revealed a high and increasing level of inbreeding, with its potential negative impact on breed performance.

The findings of the study indicated that the Stud needed to increase the selection pressure applied and improve its management of the animals. The results also supported a decision taken in 1989/90 to open the Stud herd and bring in new breeding stock to reduce inbreeding and broaden the genetic base.

A separate study in 1990/91 assessed the performance of Friesian bulls at the national AI Stud. Artificial insemination (AI) of dairy cattle has been widely practised in Kenya since the 1940s. By the 1960s, demand for semen had outstripped supply available from imported dairy bulls and the Kenyan Dairy Cattle Improvement Programme established two new programmes, the Progeny Testing Programme (PTP) and the Contract Mating Scheme (CMS). The PTP aimed at determining the genetic merit, or breeding value, of bulls at the AI Stud, using production records of their daughters raised in Kenya. The object of the CMS was to produce bulls for use by the AI Stud, using superior local cows inseminated with imported semen and semen from top progeny-tested local bulls. However, up to 1990 the programmes had never been comprehensively evaluated.

In 1990/91, staff from the Kenya Dairy Cattle Improvement Programme, working with ILCA scientists, analysed a total of 28 065 lactation milk yield records, 8367 records for age at first calving and first lactation milk yield, and 9446 records for calving interval from daughters of Friesian bulls at the AI Stud. These records covered a 20-year period, from 1968 to 1987.

The analyses clearly showed that, early in its life, the PTP was having the desired effect and the quality of the bulls in the AI Stud was increasing. ("Quality" here refers to a bull's ability to father cows that give superior milk yields.) However, from 1977–79 onwards the genetic merit of the bulls began to decline.

These results have both positive and negative aspects. The early progress shows that there is potential for increasing dairy productivity through bull testing and selection. The poor performance in later years largely reflects difficulties in maintaining an effective recording scheme together with increasing demand for semen. Because of the high demand for semen, most bulls tested were retained and used by the Stud. In consequence, no selection was applied and many of the bulls in the Stud had negative "proofs" — i.e. the productivity of their offspring is below the average for the population. Using such bulls in the AI programme reduces overall herd productivity rather than enhancing it.

As a result of this study, recommendations were made for the reorganisation of the Kenyan national breeding plan and its management. The prospects for increasing the productivity of the national Friesian herd (and the Ayrshire, Jersey and Guernsey herds, which are also covered by the AI Stud) were thus improved.

Conservation of animal genetic resources

Following on from these activities in breed characterisation, in 1992 ILCA organised and hosted a research planning workshop to develop a plan of action covering inventory of African animal genetic resources, establishment of breed development strategies and development of a programme of training for those involved in the project. This initiative links with the global plan launched by FAO "to preserve the ancestral gene pool of domestic animals in the developing world."

The initial phase of this research was aimed at developing, in collaboration with NARS and FAO, baseline information on Africa's livestock — number of breeds, sizes of populations and the production environments in which they are found. The first step in the process was compilation of information from the literature — both conventional and "grey" — to determine what information was already available and what additional information needed to be collected.

During 1992 ILCA scientists reviewed available information on taurine cattle breeds in West Africa.

West African taurine cattle breeds include the hamitic longhorns (*Bos taurus longifrons*) and the shorthorns (*Bos taurus brachyceros*). Only two longhorn breeds are found in West Africa — the N'Dama and the Kuri. The shorthorn population is much more varied. Shorthorn breeds are known by a variety of names, depending largely on location, including Muturu (Nigeria and Liberia), Lagune (Côte d'Ivoire, Togo and Benin), Ghana Shorthorn, Baoulé (Côte d'Ivoire and Burkina Faso), Somba (Togo and Benin), Bakosi, Bakweri, Doayo and Kapsiki

(Cameroon), Lobi (Burkina Faso and Côte d'Ivoire), Gambian Dwarf, Manjaca (Guinea Bissau) and Logone (Chad). However, it is not clear whether all these populations are different enough to deserve different names.

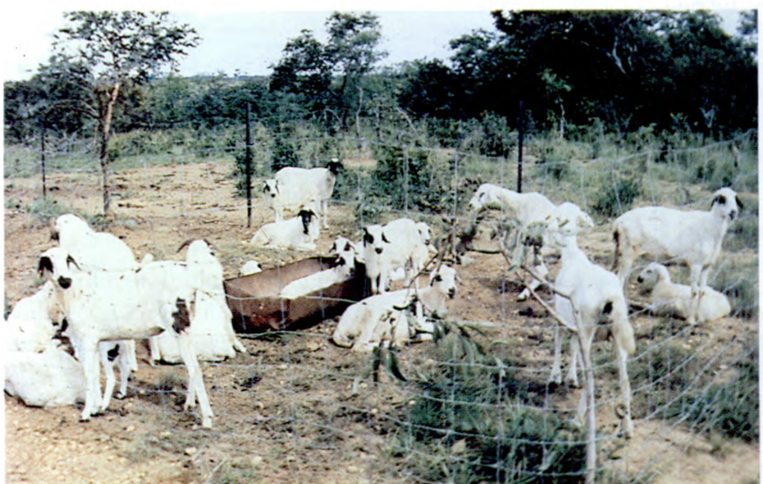
With the possible exception of Kuri, which lives in a very special environment where tsetse flies have not been recorded, these breeds have developed in tsetse-infested areas and are thought to have developed varying degrees of trypanotolerance. The N'Dama is the best known, most numerous and most widely spread of the trypanotolerant breeds. With a total of nearly five million head spread throughout West and central Africa, the N'Dama is not endangered. However, the total population of all West African Shorthorns together is in the region of only two million head, and several breeds, including the Muturu and Lagune, are at risk of disappearing, mainly because of cross-breeding (especially with zebus), neglect and reducing areas of pastoral land as population pressure increases.

The review of West African taurine cattle breeds was aimed at determining the extent to which these breeds are endangered and at identifying information gaps that need to be filled in order to adequately characterise and evaluate the breeds and eventually defend efforts to conserve them. The reviews primarily addressed breed origin, distribution, population statistics, habitat, management and production systems, breed description, adaptability, disease resistance and performance characteristics. Such information is needed to assess the potential of the breeds.

Small Ruminant Meat and Milk Thrust

The Small Ruminant Meat and Milk Thrust had five research themes:

- Economics of small ruminant production



ILCA's breed characterisation work also addressed small ruminants, such as the Djallonke, seen here in northern Nigeria.

- Genetic resource evaluation and breed improvement
- Forage production and feeding systems
- Reproductive wastage and health management
- Management systems.

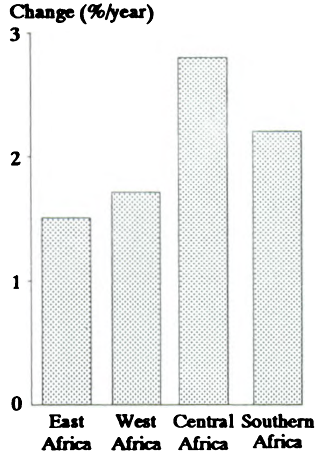
Economics of small ruminant production

An understanding of the economic constraints to and opportunities for small ruminant production and marketing in sub-Saharan Africa, and the socio-economic conditions in which the systems existed, was considered a prerequisite for developing appropriate interventions to increase small ruminant production.

ILCA conducted numerous marketing and consumption studies, primarily in support of zonal research programmes in Ethiopia, Kenya, Mali, Niger and Nigeria. The Centre also carried out an overall study of patterns of marketing and demand in sub-Saharan Africa. Aggregate data from FAO production and trade tapes were used to determine regional patterns and trends in small ruminant meat production, trade and consumption.

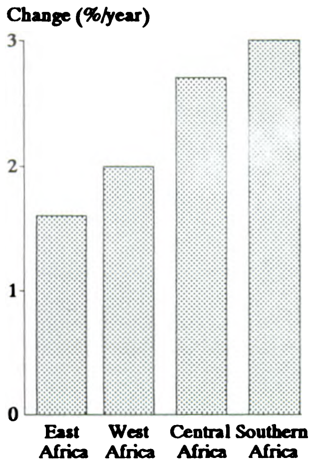
Aggregate statistics for sub-Saharan Africa showed that East and West Africa accounted for 90% of the region's small ruminant stocks and for 92% of its small ruminant meat consumption in 1986/87. However, between 1961/65 and 1986/88, there were marked differences between regions in changes in small ruminant stocks (Figure 20) and in small ruminant meat consumption (Figure 21).

Figure 20. *Changes in small ruminant stocks, 1961/65–1986/88.*



There were also regional differences in levels and trends in slaughter offtake rates (Figures 22 and 23) and carcass yields (Figure 24).

Figure 21. *Changes in small ruminant meat consumption, 1961/65–1986/88.*



A comparison of growth rates in small ruminant population, offtake and carcass weight revealed that offtake had been excessive in relation to flock growth and productivity in some regions of sub-Saharan Africa This was especially true in southern Africa where, between 1974/76 and 1986/88, small ruminant (particularly sheep) offtake rates increased faster than small ruminant stocks and carcass weights. The slow growth of flocks and the decline in carcass yields in this region indicated that production systems would not be able to meet demand for small ruminant meat in coming years. While no definite conclusions could be drawn from the study, the aggregate figures emphasised the need to increase production of small ruminant meat in sub-Saharan Africa in the face of rapid population growth.

Another important aspect of the economics work under the small ruminant thrust was to assess the profitability of interventions that had showed promise in on-station and on-farm trials. One such study, in 1992, examined the economics of all the on-farm strategic feeding trials conducted by ILCA in the Ethiopian highlands since 1985. Production data from eight on-farm experiments were analysed using partial

Figure 22. *Average smallstock offtake rates, 1986/88.*

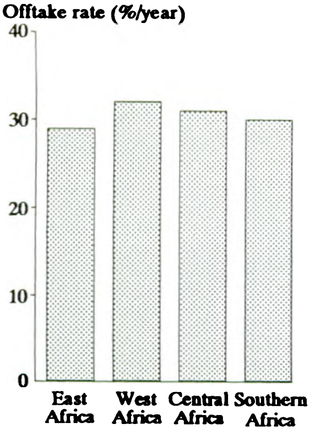


Figure 23. *Change in small ruminant slaughter offtake rates, 1961/65–1986/88.*

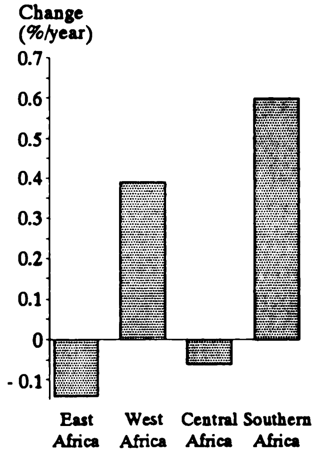
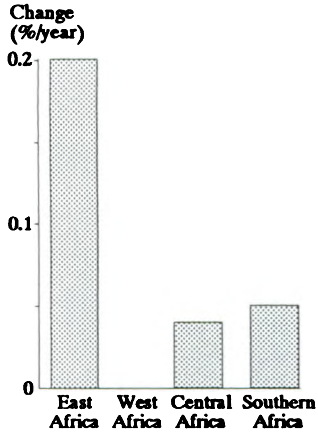


Figure 24. *Changes in carcass weights, 1961/65–1986/88.*



budgeting to assess the financial viability of fattening sheep for sale during strategic periods of the year.

The results showed that farmer income could be increased by strategic feeding of sheep to fatten them for sale during periods of peak demand, especially festivals and holidays. However, concentrates (mixed high-protein balanced rations usually made up of purchased oil seed and milled grain by-products) were the only profitable supplement to grazing or feeding straw. Growing forages and grain as supplements in strategic feeding were not financially viable alternatives. Thus, no sustainable means of intensifying on-farm feeding production had been developed.

The results indicated that need for further on-station research to develop viable forage and grain feeding packages. They also pointed to a number of socio-economic factors that needed to be taken into consideration in the design of future on-station and on-farm trials. The study indicated that, for research efforts to have an impact, the following management, technical and socio-economic factors needed to be considered:

- Resource conditions that encourage intensification of crop production do not necessarily mean that forages can replace food crops or that grains can be fed to animals profitably.
- Adequate length of fattening period and time of purchase and sale (which affect price) need to be carefully planned to achieve acceptable profitability.
- The alternative economic activities of the farm household need to be considered to ensure labour availability.

- Competition between crops and forages for land and labour needs to be allowed for and coordinated within the fattening period.

- The food preferences of farmers need to be assessed since they can determine the opportunity cost of animal feeds.

- Marketing potential, including relative market prices for feeds and food crops, need to be considered.

- Palatability, digestibility and the nutritional quality of forages need to be evaluated.

The study stressed the need to investigate these factors before trials were started and to allow for their potential effects in designing trials.

Genetic resource evaluation and breed improvement

ILCA collaborated extensively with NARS in several sub-Saharan African countries in compiling and analysing data of the productivity and characteristics of small ruminant breeds and types, and conducted its own breed evaluation work at several sites. Studies included work in Ethiopia, Mozambique, Nigeria, Rwanda, Sudan, Tanzania and Togo. These studies led to a number of publications, including CIPEA Rapport de recherche n° 15, *La productivite des petits ruminants dans les stations de recherche de l'Institut des sciences agronomiques du Rwanda*, and ILCA Research Report 18, *Evaluation of Shugor, Dubasi and Watish subtypes of Sudan Desert sheep at the El-Huda National Sheep Research Station, Gezira Province, Sudan.*

In 1991, ILCA started a new, long-term study of genetic resistance to gastro-intestinal parasites in small ruminants. In that year, ILCA held a research planning workshop to develop a pan-African research programme to investigate genetic resistance to endoparasites in small ruminants. By 1992 the research programme involved multidisciplinary studies of Dorper and Red Maasai sheep and Small East African and Galla goats in coastal Kenya; Menz and Horro sheep in the Ethiopian highlands; and Fulani and Djallonké sheep and Sahel and West African Dwarf goats in Senegal.

In the mixed crop–livestock systems of Africa, most smallholder farmers raise their small ruminants at least partly on communal grazing lands. Consequently, whenever climatic and management conditions permit, endoparasites can cause large production losses. Most control efforts focus on reducing pasture contamination using controlled grazing and/or anthelminthic treatment. However, the effectiveness of this approach is limited by uncertain availability and high costs of anthelminthics and limited scope for controlled grazing. Using animals resistant to endoparasites would thus appear to be an attractive low-cost option for smallholders.

Endoparasites are a problem for sheep and goat farmers throughout the world, not just in Africa. Consequently, there has been considerable interest in the possibility of developing animals that are genetically resistant to endoparasites. This is becoming particularly important in those countries where widespread use of anthelminthics is resulting in high levels of resistance to them, such as in Australia and New Zealand.

By 1992, studies in coastal Kenya were already showing clear signs that the local Red Maasai sheep is more resistant to endoparasites than is the introduced Dorper sheep breed.

ILCA's study was carried out at the Diani Estate of Baobab Farms, 20 km south of Mombasa. In January and February 1991, 229 Dorper ewes and 207 Red Maasai x Dorper (F_1) ewes were separated into 12 groups per breed. The ewes in each group were then all mated by a single ram of either the Dorper or the Red Maasai breed (single-sire breeding groups). A diallel system was employed, such that each ram was mated to approximately equal numbers of the two ewe breed types (i.e. Dorper and F_1). The same ewes plus their replacements, and 19 Red Maasai ewes, were mated again in November and December 1991 using a diallel mating system. The 12 rams of each breed used in the second mating were largely different from those used in the first mating. The rams were obtained from as wide a range of sources and districts as possible; this ensured that they were a broad and representative sample of the breeds.

The 1991 lamb crop faced a low endoparasite challenge between birth and weaning. In the 1991 lamb crop there were no significant differences in faecal egg counts (FEC) between lamb breed groups at any ages between birth and 450 days old. However, lambs with a greater proportion of Red Maasai blood had higher packed cell volumes (PCVs) — a measure of anaemia — than did Dorper lambs (Figure 25). The $^3/_4$ Red Maasai lambs had PCVs of 1–3% higher than the Dorper lambs; this difference was significant at all ages except weaning. The overall mortality between birth and 450 days of age ranged from 23% in $^3/_4$ Red Maasai lambs to 45% in Dorper lambs. Sire breed had a significant effect on lamb mortality: Dorper-sired lambs had a mortality rate of 41%, compared with 23% for Red Maasai-sired lambs.

The 1992 lamb crop faced a higher endoparasite challenge from birth to weaning. There were significant effects of breed on both FEC and PCV at weaning and 202 days of age. As the proportion of Red Maasai blood increased the FEC decreased and PCV increased. At 202 days old, $^3/_4$ Red Maasai lambs had FECs that were half those of Dorper lambs and PCVs that were 2.6 percentage points higher than the Dorpers. Mortality followed a similar pattern to than in the 1991-born lambs, with mortality decreasing as the proportion of Red Maasai blood increased. Both sire breed and dam breed had a significant effect on lamb mortality in the 1992 crop. Mortality rates were 34.6% among Dorper-sired lambs and 15.4% among Red Maasai-sired lambs, and 32.7% among lambs from Dorper dams and 21% for lambs from F_1 and Red Maasai dams.

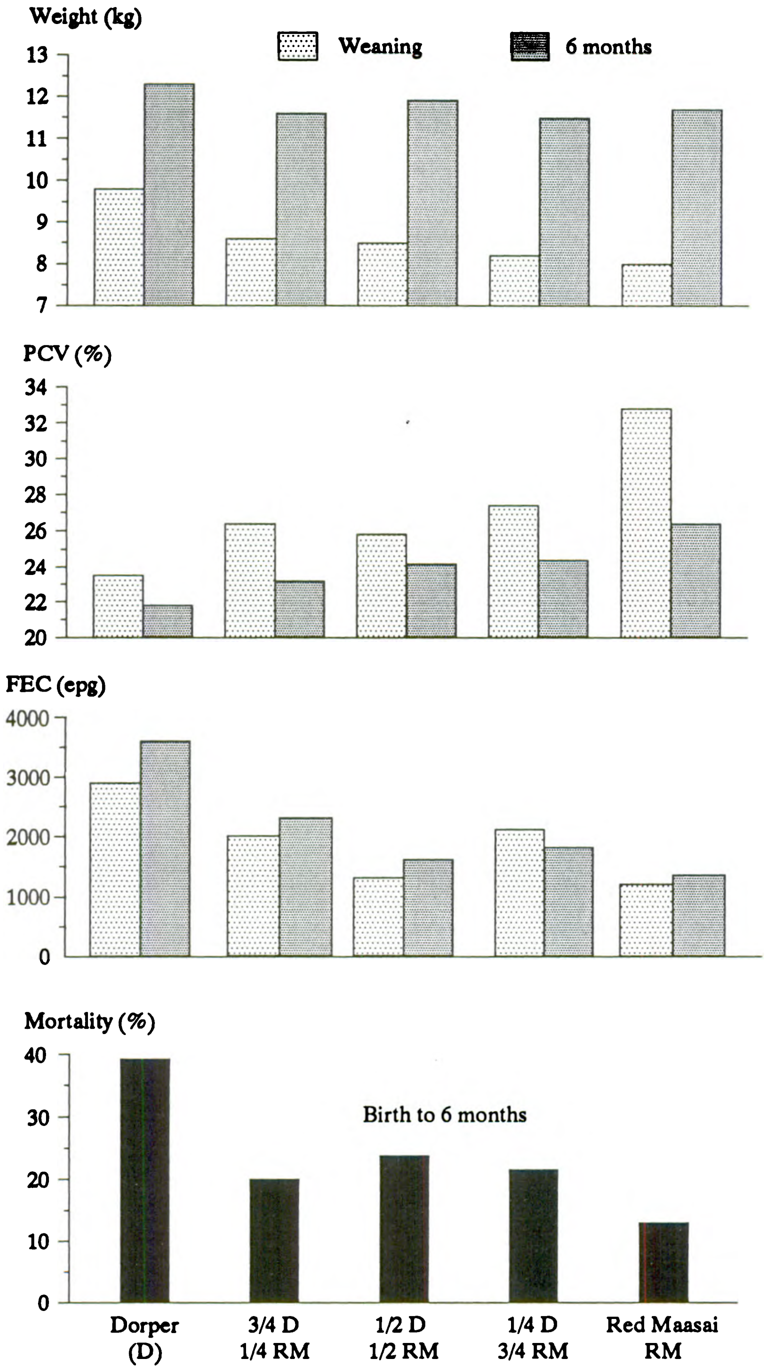


Figure 25. *Live weights, packed cell volumes (PCV), faecal egg counts (FEC) and mortality in Dorper, Red Maasai and cross-bred lambs, Kenya.*

In addition to evidence for genetic variation in resistance to endoparasites among breeds, this study also provided the first evidence for sheep in Africa of genetic variation within breeds. This is assessed in terms of heritabilities.

ILCA's studies have shown that Red Maasai sheep have genetic resistance to the main gastro-intestinal parasite found at the Kenya coast.

Estimates of heritability of both PCV and FEC increased with age, with significant levels of heritability appearing at about 10 months of age. Heritability estimates in lambs at 10 months old were 0.43±0.17 for FEC, 0.30±0.14 for log FEC and 0.24±0.16 for PCV. These compare with a heritability estimate of 0.25±0.18 for live weight at 10 months old, a trait that sheep have successfully been selected for over many years.

The preliminary results from this study suggest that the endoparasite resistance shown by the Red Maasai and its crosses, while under genetic control, is acquired rather than innate resistance. This is shown by the complete lack of significant differences in FEC among breed groups at early ages and the small differences in PCV. In the 1991 lamb crop evidence of differences in resistance did not become apparent until the animals were 12 to 15 months old. In the 1992 lamb crop these differences became apparent by weaning, possibly because of the higher endoparasite challenge the lambs faced between birth and weaning.

The increase in heritability estimates with age also suggests the development of acquired genetic resistance.

These results have important implications for studies aimed at identifying breed differences in endoparasite resistance. Had the trait been innate, screening at early ages would have been feasible. However, the clear indication that resistance develops with age implies that such studies will have to be long-term, monitoring lambs from birth until they are at least one year old.

This study also suggests that smallholders who keep sheep in the subhumid coastal zone in Kenya should be encouraged to keep indigenous stock such as the Red Maasai or crossbreds with at least 50% Red Maasai blood. A preliminary assessment of the total productivity of flocks of Dorper, F_1 and backcross (Red Maasai x (Red Maasai x Dorper)) sheep showed the highest productivity from the backcross flock (Table 17). Assuming a 20% replacement rate for ewes, the backcross flock produces twice as many yearling lambs for sale as the Dorper flock (43 vs 20). Given the very similar live weights of the lambs under the conditions at the coast, this should result in much higher returns from keeping backcrosses rather than Dorpers.

The potential impact of this research effort is huge, as the simple example of a 100-ewe flock on the Kenya coast demonstrates (Table 17). Over 60% of all smallholders at the Kenya coast keep sheep — using endoparasite-resistant Red Maasai sheep could double their annual lamb crop. Extend that through the rest of Africa, and the implication is obvious. Losses due to endoparasites will be reduced; farmers will no longer have to rely as much on chemical control of endoparasites, freeing scarce financial resources for other applications; and reducing reliance on drugs to control endoparasites will reduce environmental contamination and reverse the trend towards development of drug-resistant strains of endoparasites.

Table 17. *Aspects of flock productivity in Dorper, F_1 (Red Maasai x Dorper) and backcross (Red Maasai x (Red Maasai x Dorper)) flocks in coastal Kenya. The table presents results for a 100-ewe breeding flock.*

Trait	Dorper	F_1	Backcross
Ewes lambing (%)	70	70	81
Lambs born/ewe lambing (%)	103	103	101
Lambs born	72	72	82
Lamb mortality, birth to one year (%)		45	30
Yearling lambs reared	40	50	62
Yearling sheep for sale[1]	20	30	42
Yearling live weight (kg)	22	21.5	21

1. Assumes 20% ewe replacement rate.

Forage production and feeding systems

ILCA's work on forage production and feeding systems focused largely on incorporating leguminous forage and browse species in production systems and on making best use of feeds already available to smallholder farmers. There was also increasing emphasis on crop–livestock integration, and on system sustainability.

Humid zone

In the humid zone of West Africa, the main focus of ILCA's work continued to be on the use of leguminous fodder trees to provide feed for small ruminants and to help maintain soil fertility in alley-farming systems (see Chapter 3, *"Humid zone,"* page 49 *et seq*, and *"Browse production and use,"* pages 50–52).

ILCA studies in 1990 showed that, given the prices at the time, it was more profitable for Nigerian farmers to feed the tree foliage to their goats than to apply it as mulch to their maize crop.

Scientists monitored goat feeding in two villages in south-western Nigeria. In both villages goats roamed freely during the day, scavenging, grazing and browsing. In the evenings they returned to the vicinity of their owners' houses, where they were offered feed consisting mostly of household wastes and cassava peel and tubers, with or without browse.

Animals belonging to browse feeders received browse about twice a week. Those that belonged to non-browse-feeders received browse only one day every three months, on average. Browse feeders offered their animals a total of about 400 kg of browse over the year, compared with less than 10 kg offered by non-browse-feeders.

The biggest difference between flocks was in adult survival. Only 8% of browse-fed adults died during the year, while 20% of adults in non-browse-feeders' flocks died. As a result, the productivity of browse-fed flocks was 44% greater than that of flocks that did not receive browse (11.3 vs 7.8 kg of surviving offspring at 12 months old per surviving doe per year). On the basis of the average number of adult does in browse feeders' flocks, this equated to an extra 21.4 kg of yearling goat per household per year, or roughly two extra animals.

Agronomy studies indicated that if the amount of tree foliage fed to these animals were used as mulch it would increase maize grain yield by 22 to 28 kg. At 1990 prices for maize (5 Naira/kg)[1] and goat meat (15 Naira/kg live weight), farmers thus would gain more from feeding their goats than from mulching their maize crop.

1. US$ 1 = 10 Naira.

Subhumid zone

While the primary focus of ILCA's work in the Nigerian subhumid zone was on cattle, particularly the use of fodder banks to supplement them

Feeding browse to small ruminants reduced adult mortality rate and increased flock productivity by 44%.

during the dry season (see Chapter 3, *"Fodder banks,"* pages 53–55), the programme also carried out some studies on small ruminant production. These largely focused on farmers' adaptation of the fodder-bank concept to use with small ruminants.

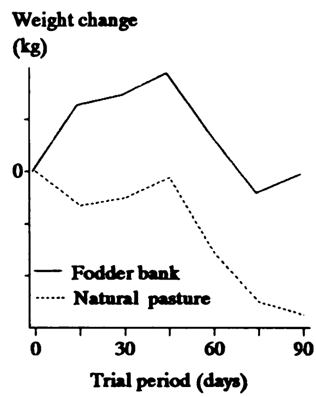
As is common elsewhere, more farmers in this zone own small ruminants than own cattle (70 vs 30%). One of the problems these farmers face is what to do with their sheep and goats during the cropping season. For most of the year, small ruminants are allowed to roam freely, foraging for themselves. During the cropping season, however, their movement has to be restricted to prevent them from damaging crops. Commonly, this has meant tethering them on natural pastures.

ILCA's scientists noticed that farmers in northern Nigeria were establishing fodder banks and confining their small ruminants on them during the wet season. This represented a radical departure from the original concept of the fodder banks as a source of dry-season feed for cattle, in both species and time of use. Starting in 1989, ILCA began monitoring farmers' practices to evaluate this new use and determine if further research was needed in support of the farmers' initiative. The practices compared included tethering goats on natural pasture, free-range grazing on enclosed natural pasture, and free-range grazing on fodder banks.

Surprisingly, wet-season management did not significantly affect survival of kids up to one year old, nor did it affect the kids' weight gains. Fodder-bank grazing did, however, significantly reduce the amount of weight does lost during the latter part of wet season. All the animals lost weight towards the end of the wet season as the amount of feed available to them declined. However, over the wet season as a whole, does grazing on fodder banks lost only 50 g, compared with a weight loss of nearly 1.5 kg for those grazing on natural pasture (Figure 26).

These benefits are relatively small, and may not have accounted for the willingness of farmers to invest in fodder banks. This willingness lay more in the benefits of fodder banks to cropping. Crops grown on land that had been under stylo gave much higher grain yields than those that followed natural pasture. Maize yielded more than three times as much grain inside fodder banks as outside (1.7 t/ha vs 0.5 t/ha), while sorghum and millet yields almost doubled to 1.2 and 0.9 t/ha, respectively. Crop-residue yields also increased by similar amounts, an important consideration as residues form a large part of the dry-season diets of livestock in the zone.

Figure 26. *Effect of fodder-bank grazing on wet-season weight loss of small ruminants, sub-humid zone, Nigeria.*



The crop yield increases stemmed from increased soil fertility together with improved soil structure and condition under the stylo. Research in 1991 showed that the nitrogen content of the soil under stylo increased by up to 75% within two years (from 0.84–0.91 g N/kg under natural pasture to 1.1–1.48 g N/kg under the fodder banks). A range of soil characteristics showed marked improvements, including bulk density, organic-matter content, water-holding capacity and cation-exchange capacity. Boosting crop yields reduces pressure on crop lands, allowing for greater fallowing. The physical improvements in the soil increase infiltration of rain water, reducing run-off and risk of erosion and reversing the trend towards environmental degradation.

Reproductive wastage and health management

Most of ILCA's research on reproductive wastage and health management in small ruminants was carried out at its research station at Debre Birhan, in the Ethiopian highlands. Much of the work focused on interactions between disease and nutrition.

Trials were conducted that examined the interactions between nutrition and disease, in particular the effects of endoparasites on productivity. Up to half of all sheep deaths and morbidity on farms in the Ethiopian highlands are caused by pneumonia and endoparasites (worms and flukes). More than a third of all the animals that die are lambs between four days and four weeks old, the period when lambs are first turned out into the field. Weaning also sees a peak in deaths, with over 30% of animals dying being between three and six months old.

The results of trials conducted at Debre Birhan in 1990 suggested that better feeding would help reduce these losses. The trials showed that feed supplementation had more effect on the productivity of ewes and on the survival and growth of lambs than did drenching the ewes against gastro-intestinal parasites.

Supplemented ewes gained 5 kg more than traditionally managed ewes, and over 3.5 kg more than unsupplemented ewes that had been drenched. Supplementation also more than doubled ovulation rates (from 17 to 37%), while drenching alone had no effect. Both supplementation and drenching of ewes increased lamb survival, but supplementation had more effect. Ewe supplementation increased milk yield, lamb growth rate to weaning, and weaning weight. Drenching alone had no effect on these characters. There was no interaction between feeding and drenching.

In a separate trial, the supplementary feeding of female lambs increased daily liveweight gains by 6 to 26 g a day, increased conception at first oestrus by 9 to 16%, reduced overall mortality by 24 to 31% and reduced age at first lambing by two to five months. Again, drenching alone had no effect on any of these characters, and there was no interaction between feeding and drenching.

Clearly, these results offer smallholder farmers a viable alternative to using chemicals to control disease problems in the Ethiopian highlands.

Management systems

This theme continued the systems identification work started by ILCA in its early years. Studies evaluated smallholder production systems and management practices as the basis for subsequent studies aimed at developing improved forage and feeding systems and management practices. Studies were conducted in Botswana, Burundi, the Ethiopian highlands, Kenya, Mali, and south-east Nigeria.

Studies in Mali

ILCA's studies of traditionally managed small ruminants in central Mali have shown large differences in productivity between flocks within production systems (see Chapter 3, *"Semi-arid zone,"* page 56 *et seq*). In 1988, the Centre conducted further studies to identify management and socio-economic factors that caused these differences. Data were collected on some 1500 small ruminants in 65 flocks at four sites around Niono, central Mali.

The results indicated that differences in productivity between flocks were greater in the millet subsystem than in the rice subsystem. Factors that appeared to have had a large effect on productivity included:

- the use of children aged between 5 and 15 years to manage goat flocks
- supplementary feeding and
- animal housing.

Dairy goats in Burundi

Dairy goat production has often been seen as a way of improving smallholders' welfare where land is scarce. However, the Ngozi project in Burundi is one of the few development projects promoting crossbred dairy goats. ILCA, in collaboration with the Projet caprin de Ngozi, conducted a study to compare the productivity of crossbred goats on stations and farms, and to evaluate their role in the functioning of the farming system and their economic benefits at the farm level. The study

In Mali, flocks managed by children were less productive than those managed by adults.

covered more than 200 farmers' flocks with a total of some 1500 animals. Fortnightly farm-budget surveys were carried out on 25 farms.

Participating farmers (i.e. those with crossbred goats) and non-participating farmers (those who kept only local breeds of animals) had similar gross margins from cropping. However, the contribution of livestock varied: farmers with crossbred goats had a margin from livestock equal to half the margin from cropping, while non-participating farmers spent more on their livestock than they earned. Off-farm income of participating farmers was less than that of non-participating farmers, although overall income was similar. Managing the crossbred goats required more labour than did traditional goat management, and tended to substitute for off-farm employment.

The study also found marked differences among farmers, with differences being related to two main factors: farmer's age (older farmers had larger farms and had more coffee bushes and banana trees); and the size of the goat flock and the proportion of crossbred goats. The sample of farmers thus needed to be divided into a number of categories:

- young traditional farmers
- young farmers with only crossbred goats
- young farmers with large goat flocks in which Small East African goats were still a majority
- older farmers with large flocks of crossbred goats
- older farmers with small flocks, largely of crossbred animals.

These different farmer-types had similar total incomes from on-farm and off-farm activities. However, they differed in several ways. For example, young farmers with flocks dominated by crossbreds were building up their flocks and spent more on their stock than they earned from keeping goats. Older farmers with a large flock of crossbreds earned more from goats than from cropping and had no off-farm income. Older farmers with smaller flocks had almost no income from livestock.

These studies clearly demonstrated the range of benefits that can accrue from a development initiative such as promoting crossbred dairy goats, and highlighted the need for identifying "recommendation domains" for accurate targeting of interventions.

Animal Traction Thrust

The Animal Traction Thrust had four research themes:

- Intensified and diversified use of draft animals
- Introduction of animal traction into new areas
- Feeding strategies for draft animals
- Alternative sources of draft power.

Intensified and diversified use of draft animals

Most agricultural operations in sub-Saharan Africa are done by hand, and seasonal labour shortage is one of the main factors contributing to low agricultural productivity in the region. Smallholders have too little land and capital to invest in tractors or other motorised machinery. Intensifying the use of animal traction could release farm labour for activities other than cultivation and provide opportunities for raising farm income. Labour productivity on the farm could be further increased by diversifying the use of animals for secondary cultivation, carting, water lifting and other operations that require tractive power.

ILCA focused its efforts under this theme through the Joint Vertisol Project (JVP), a collaborative project started in 1986 that aimed at developing and verifying improved Vertisol management techniques in smallholder mixed farming systems in the Ethiopian highlands (see Chapter 3, *"Importance of Vertisols,"* pages 43–45).

The first version of the broadbed maker (BBM) developed by the JVP required substantial modifications to the local plough, or *maresha* (Figure 27). Farmers testing the BBM identified a number of problems with it: it was too heavy to transport, difficult to manufacture and could not be stored in the traditional way. In addition, since the modifications to the ploughs were permanent, the BBM could not be used for primary cultivation.

In response to these comments, ILCA redesigned the BBM in 1987, simplifying its construction. The new version is assembled without any change to the *maresha*. Two ploughs are tied together in a triangular form and a pair of sheet-metal wings is slipped over the ploughs (Figure 28). A chain hooked to the wings acts as a harrow and leveller.

In on-farm trials, using the BBM significantly increased wheat grain and straw yields under most conditions (Table 18).

Subsequent trials showed similar results. In 1988, for example, the broadbed maker was again tested against traditional land preparation

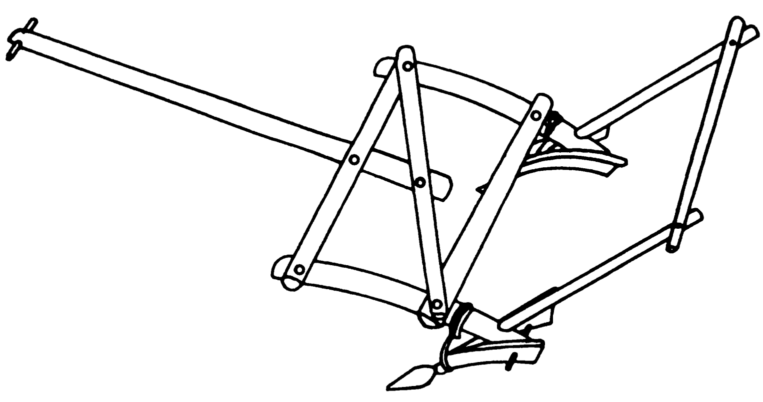
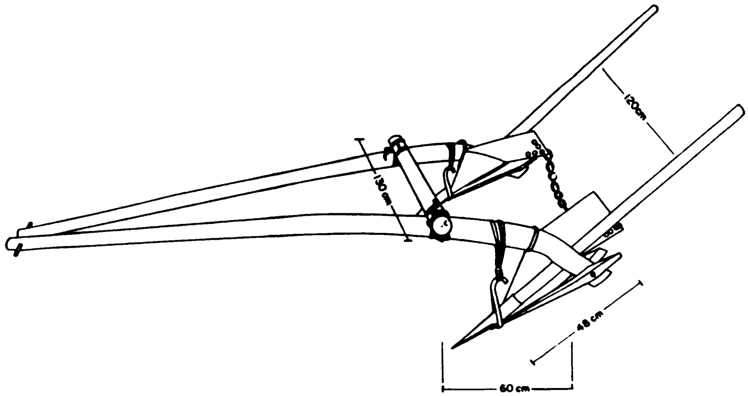


Figure 27. *Diagram of the original broadbed maker, showing the large and permanent alterations to the* mareshas *on which it is based. Compare with Figure 28.*

Figure 28. *Diagram of the 1987 broadbed maker. No permanent alterations are made to the two* mareshas *used.*



practices, in this case at Dejen, Inewari and Debre Zeit. Farmers at Dejen and Debre Zeit plant on flat seedbeds. At Inewari, farmers traditionally use broadbeds and furrows, forming the broadbeds by hand after several passes with the *maresha*. Farmers at Debre Zeit plant on a flat seedbed.

At Dejen, wheat grown on broadbeds yielded 73% more grain than that grown on flat seedbeds. At Debre Zeit the land is naturally drained and the benefits of growing crops on broadbeds was generally less. Nevertheless, yields were higher on the broadbeds, although not significantly in the case of grain.

Table 18. *Wheat yields at Were Ilu, Wello, and Debre Zeit, Shewa, on Vertisols, as influenced by surface drainage and fertiliser inputs, Ethiopian highlands, 1987.*

Crop and land preparation	Fertiliser application[1] (kg/ha)	Average grain yield (kg/ha)	Average straw yield (kg/ha)
Were Ilu			
BBF[2]	0	1090	1384
	50	1376	1664
	100	1696	2062
Traditional[3]	0	770	990
	50	1073	1302
	100	1170	1415
Debre Zeit			
BBF	100	1847	3814
Traditional[4]	100	1119	2690

1. Diammonium phosphate (DAP).
2. BBF = Broadbeds and furrows, beds 120 cm wide.
3. Ridge and furrow, ridges 30 cm wide.
4. Flat seedbed.

Several attachments to the broadbed maker were tested, including this hand-metered seed drill.

At Inewari, where the comparison was between broadbeds made by hand and those made using the BBM, there was no significant difference between the treatments, although crops grown on the BBM-made broadbeds tended to give higher yields. However, the BBM made the broadbeds faster and better, increasing labour productivity. Making broadbeds by hand, a task commonly done by women and children, took about 60 hours/ha; using the BBM it took only 16 hours/ha. Altogether, land preparation, seeding and drainage took about 120 hours of work for each hectare in the traditional system, compared with about 75 hours using the BBM. This gave a 40% increase in labour productivity, even if the yields remained the same.

Building on this system, ILCA scientists investigated two ways of further increasing the productivity of Vertisol cropping in the highlands — sequential cropping and intercropping. In each case, ILCA's interest was in introducing forage crops into the cropping system to boost the availability and quality of feed for livestock.

The sequential cropping system tested consisted of planting a forage crop at the beginning of the rains, followed by a traditional, late-season crop planted at the normal time towards the end of the rains. Intercropping trials investigated the possibilities of combining food and forage crops.

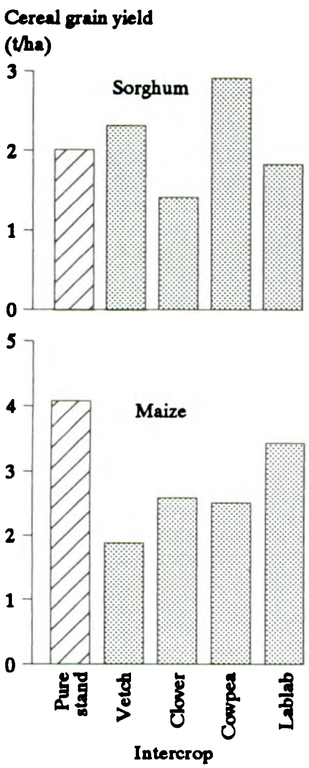
In 1991, the early-season forage crops — oats in pure stand or mixed with vetch (*Vicia villosa* subsp *dasycarpa*) — yielded an average of nearly 4 tonnes of dry matter per hectare. Crude-protein yields averaged about 280 kg/ha for oats alone and over 520 kg/ha for the oat/vetch mixtures.

The sequential cropping system simply adds a forage crop to the traditional cropping system. The forage crop produced is thus almost pure gain to the system. Under the traditional system the land would have lain fallow during the time the forage crop was growing. Indeed, the forage crops increase the sustainability of the cropping system by reducing soil erosion — leaving the soil bare during the rains exposes it to droplet and run-off erosion.

Yields of the four traditional crops grown after the forage crops — chickpea (*Cicer arietinum*), India pea (*Lathyrus sativus*) and two local durum wheat cultivars — were similar to those of crops that followed a fallow period.

The benefits to the farming system of sequential cropping are thus clear. Including an oat/vetch forage crop in the cropping system provides enough high-quality feed to support a crossbred dairy cow producing an average of 4 kg of milk a day for up to 15 months.

Figure 29. *Effect of intercropping with forage legumes on the grain yield of sorghum and maize.*



Intercropping trials in 1991 at ILCA's Debre Zeit research station tested four food crops — wheat and oats, commonly grown at medium to high altitudes, and maize and sorghum, which are medium-to low-altitude crops — in pure stands and intercropped with lablab (*Lablab purpureus*), clover (*Trifolium steudneri*), cowpea (*Vigna unguiculata*) and vetch.

Of the four cereals, sorghum performed best in intercrops. For example, the grain yield of sorghum intercropped with cowpea was up to 45% greater than that of sorghum grown in pure stand (Figure 29).

Oats grew well in combinations with vetch and lablab but gave markedly lower yields when grown with clover and cowpea. Maize did poorly in all intercropping combinations, grain yield falling by up to 55% when grown with vetch (Figure 29). Wheat grew reasonably well in combinations with the legumes, with only slight grain yield reductions.

In pure stands the cereals produced total feed yields (residues plus weeds) of between 7.3 and 8.8 t DM/ha. Crude-protein yields ranged from 327 to 543 kg/ha. Total feed yields of the intercrops ranged from about 8 t DM/ha to more than 11 t DM/ha. Total crude-protein yields of the intercrops were almost double those of pure-stand cereals, ranging from 526 to 1099 kg/ha, of which the cereals provided between 254 and 358 kg/ha.

The increases in dry-matter and crude-protein yields from the most productive intercropping systems were similar to those from sequential cropping. In the best combinations — particularly sorghum with cowpea — cereal production increased at the same time as the feed available for livestock increased in both quantity and quality.

Each cropping system would help increase farm productivity, but used in combination they offer even more benefits. Sequential cropping provides feed early in the wet season, while feed from intercropping becomes available later. Using a combination of the systems would thus boost feed production at different times, smoothing the pattern of feed availability, broadening the livestock production and land-management options available to the farmers.

Socio-economic studies showed that the broadbed-and-furrow system is economically attractive and readily acceptable to farmers in the Ethiopian highlands. Studies in 1991 showed that farmers, once introduced to the BBM and the broadbed-and-furrow system, continue to use it without further intervention from ILCA and even teach other farmers in their areas to use the system.

Seventy-six farmers who had been using the BBM under ILCA supervision up to 1990 continued to purchase inputs on credit and to use seed and fertiliser rates recommended by the Ministry of Agriculture. These farmers, at three sites in the Ethiopian highlands, also trained another 150 farmers in the use of the BBM and the broadbed-and-furrow system.

Farmers using the broadbed-and-furrow system obtained wheat grain yields of nearly 1.8 t/ha at Ginchi, one of the three sites monitored. Yields from the traditional system were less than 1 t/ha. Using the improved cropping systems gave gross margins for wheat production nearly triple those for the traditional system (Ethiopian birr 1449 vs EB 536; US$ 1 = EB 2.07), while net return per hectare more than tripled and return to labour more than doubled.

Yields and gross margins obtained by farmers new to the broadbed-and-furrow system were similar to those obtained by farmers experienced in the technology (1776 vs 1793 kg/ha and EB 1454 vs EB 1489).

These results demonstrated that the broadbed-and-furrow system is sustainable under farmer management, as long as inputs and credit are available when needed, and that farmer-to-farmer extension works.

Introduction of animal traction into new areas

Most of ILCA's work under this theme focused on introducing animal-powered cultivation on *fadama* land in subhumid Nigeria. *Fadamas* — seasonally inundated valley bottoms — account for about 7% of the land area of sub-Saharan Africa, an area equivalent to Nigeria. Although they are potentially very productive, they are not at present fully exploited for cropping, mainly due to shortage of labour for land preparation. However, grasses growing on residual moisture make the *fadamas* valuable for dry-season grazing.

Work started in 1987 with trials testing a number of rice cultivars. These showed that rice grain and straw yields could be markedly increased through growing improved cultivars, increasing both food and feed production. The straw of the improved cultivars also had better nutritive value than that of the traditional cultivar.

Studies were made on 1988 of the use made of *fadamas* for dry-season grazing. Cattle grazed the *fadama* for as much as two hours a day in February, late in the dry season, and in May, at the beginning of the rains. The herbaceous cover of the *fadamas* was found to regenerate early in the rains, before the plant cover on the uplands.

Using animals to plough *fadama* land was much faster than cultivating it by hand, averaging 20.4 person-seconds/m^2 with the oxen compared with 72.0 person-seconds/m^2 for hand cultivation. Trials also showed that it was possible to plough the land during the dry season using oxen, but that this was not possible using manual cultivation because the soil was too hard. This allowed the task of cultivation to be moved from the period of peak labour demand at the beginning of the rains to the slack dry season.

Subsequent trials showed that weed infestation was more of a problem in plots cultivated using oxen, particularly those cultivated in the dry season, than in plots cultivated by hand. However, weed burden did not significantly affect rice yields. Weeding was the most time-consuming activity, taking from 712 hours/ha in plots cultivated by hand in the wet season to 1241 hours/ha in plots cultivated in the dry season using oxen.

Overall, animal-powered cultivation did not result in a large decrease in total labour required to raise a rice crop. It did, however, change the pattern of labour demand, shifting tasks from periods of peak labour demand (early rainy season) to periods of less intense activity, such as the dry season (cultivation) and later in the rainy season (weeding). Farmers showed considerable interest in the techniques and several adopted them spontaneously.

Cultivating land by hand in subhumid Nigeria. Animals do the work faster and better.

Feeding strategies for draft animals

Work under this theme was mainly conducted at ILCA's Debre Zeit research station, in the Ethiopian highlands, and in Mali, in collaboration with the Institut national de recherche zootechnique, forestière et hydrobiologique (INRZFH).

Shortages of feed, and the poor quality of feed available, make it difficult for Sahelian farmers to maintain the body condition of their draft animals during the dry season (see Chapter 3, *"Nutrition of work oxen,"* pages 58–59). It has often been demonstrated in experimental trials that thin, light oxen can do less work than fatter, heavier oxen. Hence it was assumed that feeding work-oxen better during the dry season would increase the amount of work they would do.

In 1986, ILCA and INRZFH in Mali began a series of studies aimed at quantifying the effect of dry-season weight loss on the working capacity of oxen and on areas cropped in the country's semi-arid zone.

An initial survey in 1986 showed that few farmers believed that they had a problem with their work oxen. A more detailed study in 1987 showed that this may have been due to the fact that oxen worked for only two weeks of the year, and then for an average of only 4.5 hours a day. Even this was broken up into two working periods of 2.9 hours in the morning and 1.6 hours in the afternoon, with a rest period in the middle of the day of 3.2 hours.

A trial in 1987 under controlled conditions showed that over an average working day of three hours the working speed of oxen pulling weighted sleds was unaffected by liveweight changes ranging from a loss of 25 kg to a gain of 70 kg during the dry season. All animals, irrespective of their body condition at the beginning of the trial, increased their working speed from a mean of 0.82 m/second during the first week of the trial to 0.91 m/second during the second week of the trial.

On-station trials in 1988 showed similar results, supplementation during the dry season increasing the body weight and condition of the oxen but having little effect on the work capacity of the oxen.

A further assessment of the effect of various animal characteristics on capacity for work was conducted in 1989. The work undertaken by 20 oxen pairs owned by smallholders was monitored under village conditions throughout the rainy season. Working time, speed of working and force exerted were measured every four days. The oxen were weighed each month and their condition was scored every second month. At the end of the cropping season all the farmers in two villages were interviewed to determine the extent to which they used draft oxen and problems they experienced during field operations.

The oxen had a mean weight of 277 kg and an average body condition of M (ribs usually visible, little fat cover, dorsal spines barely visible) at the start of field operations at the beginning of the rainy season.

From the middle of July to the end of September all animals gained an average of 0.60 kg/day, for a final mean live weight of 325 kg, and gained in body condition to M+ (animal smooth and well covered; dorsal spines cannot be seen but are easily felt).

Of the 99 farmers interviewed, 95 used oxen for ridging and 72 used them for weeding. Between 40 and 50 used oxen for ploughing, harrowing or re-ridging, but only 24 had sown crops using ox-drawn equipment. Average daily working time, number of days worked, speed of working and force exerted by a pair of oxen for the major field operations are presented in Table 19. The force exerted in relation to the weight of the oxen pairs was generally high, with an average load on an oxen pair of 15% of live weight in ridging and 12% in weeding. However, there was little evidence of problems with oxen in work. This may have been due to heavy work being limited to short bursts. During ridging, for example, oxen worked on average on a cycle of 67 seconds, over an average field length of 51 m, followed by a break of 27 seconds while the equipment was turned at the end of the field.

Table 19. *Average daily working time, number of days worked per year, speed of operation and force exerted by an ox-pair in different field operations, Mali, 1989.*

Operation	Minutes/ day	Days	Force (N)	Speed (m/second)
Harrowing	250	3.4	652	1.07
Flat ploughing	171	2.7	825	0.85
Ridging	273	16.2	835	0.74
Seeding	na	0.9	292	na
Weeding	209	11.2	656	0.77
Re-ridging	282	2.7	708	0.72

na = not available.

At the beginning of the working period oxen pairs weighed between 404 and 762 kg. Irrespective of this wide range in weight there was no evident trend in performance in terms of speed of working, duration of working or force exerted. None of the physical characteristics assessed (live weight, size and body condition) appeared to affect working performance of oxen under practical conditions. These results suggested that dry-season supplementation and weight gain would not improve work output and would be unlikely to increase the amount of land cropped or crop production.

Alternative sources of draft power

Where animal traction is used in Africa the opportunity costs of supporting the required number of oxen is considerable because the animals work for only short periods during the year — primarily for land

Ploughing with cows in the Ethiopian highlands. Using cows as draft animals can help increase farm productivity and reduce stocking rates.

preparation and threshing. Replacing draft oxen with cows could increase farm productivity, since the cows would produce milk and calves in addition to draft power.

Some farmers in the Ethiopian highlands already keep crossbred (Friesian x local zebu) dairy cows, introduced as part of a package to stimulate smallholder dairying. These cows are larger and heavier than the local oxen usually used as draft animals, and should be able to perform the work needed on smallholdings.

However, producing milk and maintaining a pregnancy already puts these dairy cows under stress. Making them work as well could reduce both their milk yield and their reproductive performance.

In 1989, ILCA began a series of experiments, in collaboration with the Ethiopian Institute of Agricultural Research, to determine the effects of work and feed supplementation on the productive and reproductive performance of crossbred cows.

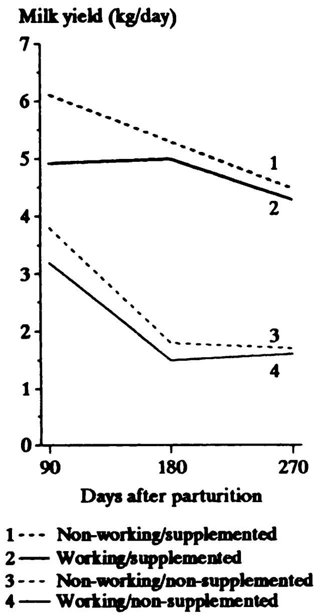
The first trial involved 40 F_1 crossbred cows, 20 Friesian x Boran and 20 Simmental x Boran. All the cows in each breed group were fed hay made from local unimproved pasture. Half of them received in addition a supplement of oilseed cake, wheat millings, salt and bone meal. Half of the cows on each diet were worked, half were not.

Cows receiving supplementary feed had significantly higher hay dry-matter intakes than cows fed hay alone (3082 vs 2813 kg in 365 days, and 6017 vs 5609 kg in 730 days). Total dry-matter intake followed a similar pattern (3985 vs 2813 kg in 365 days and 7525 vs 5609 kg in 730 days). Working cows had significantly higher hay dry-matter intakes (3118 vs 2777 kg in 365 days and 6207 vs 5420 kg in 730 days) and total dry-matter intakes (3585 vs 3179 kg in 365 days and 7006 vs 6128 kg in 730 days) than non-working cows.

Working cows thus increased their dry-matter intake to sustain milk production and support energy expenditure for work. The increase in hay dry-matter intake by non-supplemented working cows indicates that, when supplements are scarce, working cows will increase their forage intake in order to provide energy for work.

Total milk production in the two-year experimental period was similar for working and non-working cows (1985 vs 2225 kg). However, supplementation had a much larger effect on milk production than did work: supplemented cows produced significantly more milk than non-supplemented cows (3115 vs 1095 kg) (Figure 30). Friesian x Boran cows produced significantly more milk than Simmental x Boran cows (2352 cv 1859 kg).

Figure 30. *Effect of work and supplementary feeding on milk yield of crossbred cows, Ethiopian highlands.*



Non-supplemented cows lost weight throughout the two-year period, whereas supplemented cows maintained their initial body weight except in the case of working cows during the first (90 days) and last (540 days) working periods. Working and non-working cows had similar total body-weight losses (-54.5 vs -41.2 kg in 730 days). The total body-weight loss of non-supplemented cows was significantly greater than that of supplemented cows (-77.8 vs -15.5 kg in 730 days). The total body-weight loss of supplemented working cows was much less than that of non-supplemented working cows (23.4 vs 85.6 kg in 730 days).

The increase in hay dry-matter intake in non-supplemented working cows was thus insufficient to provide the energy the cows needed. Non-supplemented working cows continued to lose body weight and their milk production and reproductive functions stopped as a result. In contrast, supplemented cows were able to work and produce milk without adverse effects on their body weight.

Diet supplementation significantly reduced days to first oestrus and days to conception in both non-working and working cows. Supplemented working cows had similar reproductive performance to that of non-supplemented/non-working cows.

Overall, the results show that crossbred dairy cows could be used as draft animals, if farmers can feed them adequately. The slight reductions in milk production and reproductive performance should be more than offset by the value of the work performed by the animals.

Animal Feed Resources Thrust

The Animal Feed Resources Thrust had four research themes:

- Services and resource assessment
- Initial evaluation of feed resources
- Multipurpose trees
- Legume forages in crop–livestock systems.

Services and resource assessment

Increasing livestock production depends to a large extent on the availability of suitable feed resources. This theme focused on determining the potential feed supplies in various agro-ecological zones and on assembling a varied forage germplasm collection. Earlier work on these topics was reported in Chapter 3 under *"Forage Agronomy Section,"* pages 80–82.

The main service activities of ILCA's feed resources work related to the Forage Genetic Resources Section and the Herbage Seed Unit. The activities of the former were funded largely by Germany, while the latter was funded by Switzerland.

Forage genetic resources

By 1994, the ILCA genebank held more than 12 000 accessions from 840 species of 227 genera (Table 20). The major genera identified as potentially useful forages are widely represented. The germplasm held by the genebank is freely available in small quantities to bona fide forage research workers, and the Centre distributed an average of more than 3000 samples of seed a year in response to requests, mainly from sub-Saharan Africa.

Table 20. *Number of accessions of forage germplasm held by ILCA's genebank, May 1994.*

Forage type	African indigenous germplasm	Introduced germplasm	Total
Browse	785	1037	1822
Grass	1771	1439	3210
Legumes	3148	3773	6921
Other forages	77	186	263
Total	5781	6435	12 216

Starting in 1988, the priority in the genetic resources work changed from collection and acquisition of forage germplasm more towards adequate characterisation and evaluation of the existing collections. The entire ILCA collection of *Sesbania* was characterised for selected morphological and phytochemical characters in 1993.

The morphological characterisation of *Sesbania sesban* was completed at Zwai on six-month old trees. Principle component analysis on the whole data set indicated two main groups of accessions. One contained all *S. sesban* var *sesban* and *bicolor* accessions and the other was comprised of accessions from the variety *nubica*. These groups were mainly based on differences in number of leaflets per compound leaf and the size of the leaflets. Further analyses of anti-nutritional compounds in accessions of *S. sesban* and *S. goetzei* and artificial hybrids between them showed a higher amount of soluble phenolics and proanthocyanidins found in the hybrids than in the parents, whilst the content of insoluble proanthocyanidins was intermediate between the two parents. Insoluble proanthocyanidins are considered to be responsible for anti-nutritional effects and toxicity reactions, indicating that hybrids may have a reduced anti-nutritional effect as livestock feed.

Other important research in support of forage germplasm management included work on *in vitro* culture techniques for grasses and browse species. Species covered included *Cynodon aethiopicus, C. dactylon, Digitaria decumbens* and *Pennisetum purpureum* among the grasses and *Sesbania sesban, Erythrina brucei, Leucaena leucocephala* and *Faidherbia albida* among the browses. Research on *in vitro* culture of multipurpose trees was supported by the International Development Research Centre, Canada.

Another constraint to provision of forage germplasm is the lack of information on breeding systems, which is essential for the development of appropriate regeneration techniques for germplasm maintenance of selected accessions and for seed production for further utilisation. An experiment on inter-specific relationships was conducted to obtain information for the development of appropriate seed-multiplication techniques for species of *Sesbania* and *Trifolium*. Research on *Sesbania sesban* showed that flowers from different accessions are self-compatible, but that tripping by insects is probably necessary for pollination and seed set. A similar project on *Trifolium* species showed that *T. tembense, T. steudneri, T. lugardii, T. multinerve, T. pichisermollii* and *T. baccarinii* appear to be self-compatible and produce seeds without tripping.

Herbage Seed Unit

ILCA established the Herbage Seed Unit in 1989 with funding from the Swiss Development Corporation with the objective of strengthening national capacity to produce forage seeds and hence to promote the production, supply and utilisation of selected forage material by smallholder farmers.

In 1989 a workshop was held with representatives from national programmes to establish the work programme. Participants insisted that information and training were by far the highest priority rather than research into production systems. A joint ILCA/ICARDA (International Center for Agricultural Research in the Dry Areas) research planning workshop on smallholder seed production was held in June 1994 to help the two centres develop future programme in this area.

Training began in 1990 with one full seed-production course, which covered field multiplication through to distribution, and one for research scientists to teach them to determine seed-production potential of new accessions. Collaborative courses were subsequently held with the

International Center for Tropical Agriculture (CIAT) in 1990 and the International Maize and Wheat Improvement Center (CIMMYT) in 1991/92. Collaboration with ICARDA began in 1992 with a course in Ethiopia, followed by courses in Sudan and Ethiopia in 1993.

Seed multiplication was initiated in 1989 on 1.5 hectares at Debre Zeit with irrigation to provide a source of basic seed for use in establishing seed production in national programmes. A total of 86 promising species were originally sown, which has now been reduced to 60 with an approximate 50:50 grass:legume ratio. The range of species was increased in 1993 to include species adapted to the cool tropics in anticipation of demands for seeds for the ecoregional initiative in this agro-ecological zone.

A regional seed production capability existed in the ILCA Kaduna programme prior to the establishment of the Herbage Seed Unit. It supplied limited quantities of seed for West African NARS. Regional production sites were established in Zambia in 1990 and Cameroon in 1992 with NARS and the Heifer Project International, respectively. Production from the former is approximately eight tonnes of 10 promising forage species. Activities in Cameroon involve six species each of grass and legume.

Research in postharvest seed handling was implemented by a post-doctoral scientist at ILCA and under contract with the Natural Resources Institute in the UK. Studies are in progress to determine the effects of different harvest, threshing, and drying techniques and storage conditions on seed viability. Appropriate seed conditioning equipment, including a harvester, cleaner and scarifier were developed using a simple modified design and low cost materials.

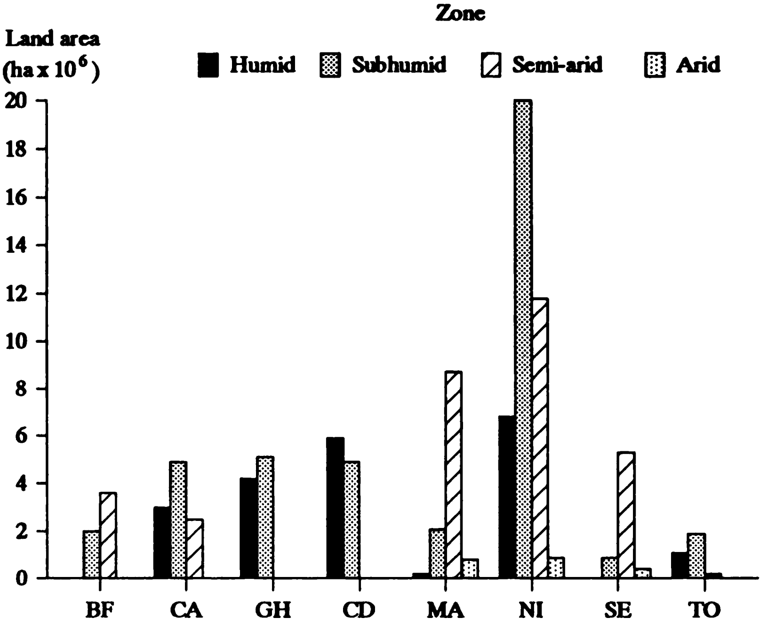
Resource assessment for forage technology development and transfer

ILCA's mandate covered all of sub-Saharan Africa, but its research activities were concentrated in a few sites and countries. Most of ILCA's work on improving livestock nutrition in the subhumid zone using forage legumes was carried out in Kaduna State in Nigeria.

In 1987 and 1988, ILCA, in collaboration with FAO, used agro-ecological zoning methodology to assess the regional relevance of research conducted at Kaduna. This methodology involves determining soil and climatic requirements of a land-use type, such as a particular crop variety, and matching these with the land resource inventories of the target area. Comparison of what is potentially possible with what is actually achievable, in terms of the fraction of the biomass that is economically useful (Harvest Index), helps to rank the land area into different suitability classes for that land-use type. This approach also indicates the type and level of inputs and management practices required to attain optimum productivity.

Assessment of land suitabilities for *Stylosanthes hamata* cv Verano — the legume used by ILCA in fodder banks — for eight West African countries revealed that the area to which this stylo is best suited falls within the 180- to 210-day growing period zone — mainly the subhumid and semi-arid zones. The vast majority of the land area suitable for growing Verano lies within Nigeria, although there are considerable areas throughout West Africa (Figure 31).

Figure 31. *Area of land suitable for* Stylosanthes hamata *cv Verano in eight West African countries.*



BF = Burkina Faso; CA = Cameroon; GH = Ghana;
CD = Côte d'Ivoire; MA = Mali; NI = Nigeria;
SE = Senegal; TO = Togo.

The extent of the land suitable for different crops was then used as the basis for estimating production potential using the Harvest Index and yield ranges for the different crops in each suitability class. Figure 32 provides an example based on the assumption that 25% of the suitable land area in Nigeria for each of the major cereal crops and Verano stylo is actually cultivated. The potential fodder production from these crops varies depending on the location and the level of inputs.

Fodder from rice and maize were of greater importance in more humid areas, while sorghum and millet were increasingly important in the drier zones. In the subhumid zone all crops were equally important. The figures suggested that, if appropriate conservation or utilisation techniques were available, maize could contribute more biomass to livestock from a given land area than the other cereals. However, no conservation techniques appropriate to smallholders were available.

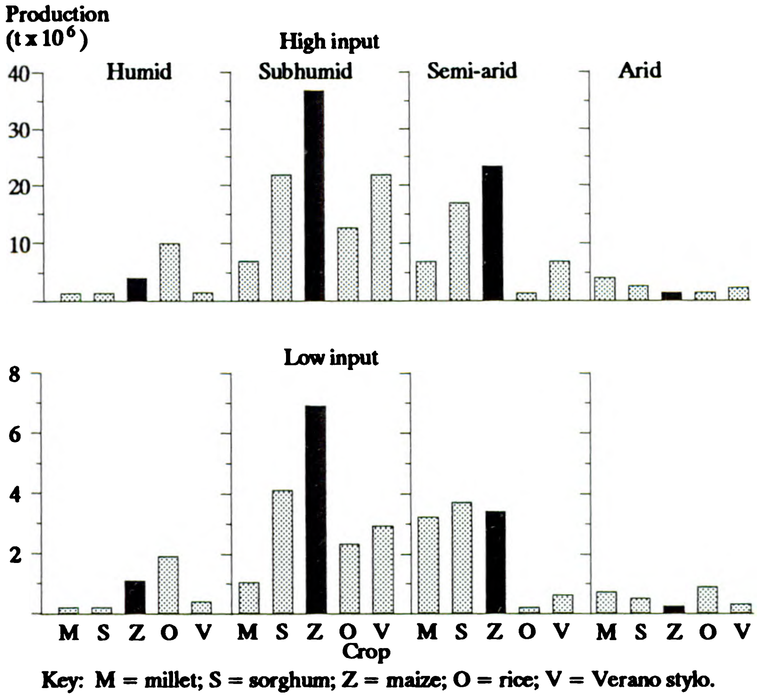


Figure 32. *Potential fodder production from millet, sorghum, maize, rice and Verano stylo under high and low levels of inputs, Nigeria.*

In 1988 the study was extended to estimate the number of animals that this feed could support during the dry season.

The amount of fodder available from millet, sorghum, maize, rice and Verano stylo was estimated for Burkina Faso, Cameroon, Côte d'Ivoire, The Gambia, Ghana, Liberia, Mali, Nigeria, Senegal and Togo. This information was then used to estimate the proportion of land suitable for each crop in each zone (humid, subhumid, semi-arid and arid) that was needed to support the livestock population of that zone (Table 21). These estimates were based on the assumptions that only part of the crop

Table 21. *Estimated percentages of land area suited to each crop in each zone needed to provide dry-season feed to support livestock populations in Nigeria.*

	Suitable land area (%)							
	Humid		Subhumid		Semi-arid		Arid	
Country	LI	HI	LI	HI	LI	HI	LI	HI
Livestock (TLU)	1 510 000		2 284 000		7 403 000		227 000	
Millet	na	na	367	47	378	159	56	8
Sorghum	na	na	90	17	326	70	66	16
Maize	262	60	67	13	451	63	133	29
Rice	44	8	51	9	3856	944	65	10
Stylo	126	11	26	3	423	35	65	10

LI = low input; HI = high input.

residue was edible (ranging from 8 to 55% of dry matter in the crop considered) and that 1.4 tonnes of dry matter were needed to support each 250 kg tropical livestock unit (TLU) for a 180-day dry season.

In some countries there were clear imbalances between livestock populations and fodder availability in some zones. For example, in Mali there is not enough fodder to support the large livestock populations in the arid and semi-arid zones, whereas in the subhumid zone the entire livestock population could be supported by growing stylo on only 5% of the land suitable to the crop, even with low inputs. This illustrated the strong, and continuing, dependence of livestock in the semi-arid and arid zones on rangelands that are unsuited for cropping.

Feed supplies could be increased by intensifying agriculture, but this would require mechanisation, improved seeds, agrochemicals, soil conservation, and food storage and delivery systems. This would be beyond the means of most African countries. An alternative would be to grow legumes such as Verano stylo; in addition to providing high-quality feed for livestock, legumes help maintain and improve soil fertility and structure, which in turn helps increase crop yields.

Further studies in 1991, in collaboration with the International Institute for Applied Systems Analysis (IIASA) showed that by the year 2000 most of the West African countries studied — Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, The Gambia, Ghana, Liberia, Mali, Niger, Nigeria, Senegal and Togo — would be unable to feed their projected human and livestock populations at current levels of inputs and management.

For the region as a whole, the results indicated that self-sufficiency in cereals, meat and milk would fall to about 50% by the year 2000.

Assuming an intermediate level of inputs for crop production activities, all the countries in the region, except for The Gambia and Nigeria, would be able to produce surpluses of cereals, meat and milk in the year 2000. In The Gambia the shortfall for all commodities would be 4%, while in Nigeria the shortfall would be 20% in all commodities.

Introducing forage legumes could support an additional 11 million TLU in the region and would increase food production by almost 30%.

Another agro-ecological adaptation study was carried out in Ethiopia between 1986 and 1988, when the performance of a broad range of tropical forage legumes was compared in a series of contrasting environments characteristic of some of the major ecological zones of East Africa. Experiments were conducted at sites at altitudes ranging from 750 m to 2000 m, with annual rainfall ranging from 562 to 1054 mm and mean annual temperature ranging from 17.9 to 26.2°C. Irrigation was used at the two drier sites to simulate a wider range of rainfall environments. The forage legumes tested were: *Calopogonium mucunoides, Centrosema brasilianum, C. pubescens, C. virginianum, Desmodium intortum, D. sandwicense, D. uncinatum, Indigofera arrecta, Lablab purpureus, Macroptilium atropurpureum, Neonotonia* *wightii* (two accessions), *Stylosanthes guianensis* (three accessions), *S. hamata* (two accessions), *S. scabra* (three accessions) and *Tephrosia vogelii* (perennials); and *Centrosema pascuorum, Crotalaria intermedia, Lablab purpureus, Macroptilium lathyroides, Macrotyloma uniflorum, Phaseolus acutifolius* and *Vigna unguiculata* (three accessions) (annuals). Accessions were evaluated in terms of mean yield and stability of yield across environments. Yields were also correlated with a range of climatic and edaphic characteristics of the different environments.

The study showed clear differences in stability of yield between perennial accessions, but not between annuals. Correlation of yields with water supply suggested that perennials responded linearly to water supply, and that differences in this response largely accounted for differences in yield stability. By contrast, annuals had non-linear responses to water supply, and this probably accounted for the lack of any significant differences in yield stability between the accessions. *Lablab purpureus* ILCA 6536, which was regarded as a perennial accession in this trial, had a high mean yield and low regression coefficient with rainfall, indicating its adaptation to a wide range of rainfall conditions.

While edaphic factors had little effect on yields of established swards, they did have a marked effect on the emergence, early survival and initial growth of many perennial accessions.

This series of trials demonstrated the need for multilocational screening of forage legumes to identify accessions that are well adapted to the environments of sub-Saharan Africa. This concept was further developed through the Pasture Network for Eastern and Southern Africa (PANESA) and the African Feed Resources Network, AFRNET, which set up a series of multilocational trials to evaluate a wide range of species across Africa to identify those accessions with potential for specific environments and farming systems.

Initial evaluation of feed resources

Increasing the feed resources available for livestock production depends on systematic evaluation of forages in a range of environments. Under this theme, forage germplasm was evaluated agronomically in Ethiopia and Nigeria and its performance in production systems was assessed under highland, humid and subhumid conditions in the same countries. Research also examined soil–plant–water–nutrient relationships and the nutritive value of feeds.

Preliminary evaluation trials of forage germplasm were carried out at Soddo in Ethiopia. This site is at mid-altitude in a subhumid environment. Materials evaluated included large collections of *Zornia, Stylosanthes guianensis, S. fruticosa, S. hamata, S. scabra* and *Neonotonia wightii*. Other sites in the highlands were used to evaluate collections of *Trifolium* species.

A series of agronomic evaluation trials were conducted at Soddo in 1988 through 1990 with 41 accessions of native Ethiopian *Neonotonia wightii*, 34 accessions of *Stylosanthes scabra* and 20 accessions of *S. guianensis* (Larbi et al, 1992a). Soddo is at medium altitude (1950 m), has a subhumid climate (average annual rainfall 1060 mm) and is on acid soil (pH 4.4). Two commercial cultivars of each species were included in the evaluation trials as checks.

Within each species several accessions gave greater dry-matter yields than the better commercial cultivar. This was particularly noticeable for *Neonotonia*, which is generally poorly adapted to acid soils. The highest yielding *Neonotonia* accession (ILCA 9794) yielded nearly six times as much dry matter as the cultivar Clarence (5941 vs 964 kg/ha). Two other ILCA accessions (ILCA 7764 and 7892) yielded over 4 t DM/ha. The yield advantage of the best accessions was less marked in the other species, with the best *S. scabra* accession outyielding the better cultivar by nearly 30% (2101 vs 1629 kg DM/ha) and the best *S. guianensis* accession outyielding the better check by 45% (8254 vs 5688 kg DM/ha). These results clearly demonstrated the need for multilocational screening of accessions under a range of environmental and edaphic conditions.

In 1989, trials were conducted at ILCA's headquarters at Shola, in the Ethiopian highlands, to determine the effect of phosphorus fertiliser on highland clovers and on biological nitrogen fixation by these clovers.

A greenhouse experiment was conducted to investigate differences among clovers in their response to phosphorus application. Twenty

Forage screening trials at Soddo, Ethiopia, a mid-altitude, subhumid site.

clover accessions from 11 species (*Trifolium baccarinii, T. decorum, T. rueppellianum, T. steudneri, T. tembense, T. pichisermollii, T. polystachyum, T. bilineatum, T. mattirolianum, T. quartinianum* and *T. schimperi*) were grown for 60 days in pots filled with Vertisol from ILCA's headquarters site. Phosphorus was applied at 0, 12.5, 25, 37.5 and 50 mg P/pot (0, 25, 50, 75 and 100 kg P/ha) as $Na_2HPO_4.12H_2O$.

Applying phosphorus at a rate of 12.5 mg P/pot significantly increased the above-ground dry-matter yield of all accessions compared with the unfertilised control, but applying larger amounts led to no further increase in the dry-matter yield of *T. baccarinii* (ILCA 8158), *T. rueppellianum* (ILCA 9690), *T. pichisermollii* (ILCA 8065 and 9960) and *T. polystachyum* (ILCA 6298). Two accessions of *T. decorum* (ILCA 6264 and 9682) produced the highest dry-matter yields. Root dry-matter yields followed generally similar trends.

The "ideal" accession or species for use under smallholder conditions is one that gives high yields when little or no phosphorus fertiliser is applied yet responds well to applied fertiliser. Based on these criteria, the best accessions were *T. decorum* (ILCA 6264 and 9682) followed by *T. quartinianum* (ILCA 6301), *T. bilineatum* (ILCA 8351) and *T. tembense* (ILCA 9681, 8635 and 8501).

The study of biological nitrogen fixation in highland clovers involved eight accessions of five clover species (*T. quartinianum, T. steudneri, T. decorum, T. rueppellianum* and *T. tembense*) grown in the field at ILCA's headquarters site. The amount of nitrogen fixed was estimated using both the nitrogen difference method, with oats as the nitrophilous reference crop, and the ^{15}N method.

The two methods gave similar results and ranking, but the ^{15}N method indicated slightly larger amounts of nitrogen fixed. *Trifolium quartinianum* (ILCA 6301) and *T. decorum* (ILCA 6264) fixed most nitrogen (Table 22). Fixation met from 84 to 89% of the nitrogen needs of the various species and accessions.

Table 22. *Biological nitrogen fixation by various clover species/accessions grown on a Vertisol at Shola, Ethiopia, 1989 (^{15}N method).*

Accession	Amount of N fixed (kg N/ha)
T. quartinianum (ILCA 6301)	122
T. decorum (ILCA 6264)	112
T. rueppellianum (ILCA 6260)	100
T. decorum (ILCA 9447)	89
T. tembense (ILCA 7102)	84
T. quartinianum (ILCA 9379)	81
T. steudneri (ILCA 9720)	75
T. steudneri (ILCA 6253)	55

Evaluation trials were also conducted in subhumid and humid zones in Nigeria. Trials in the subhumid zone were particularly aimed at finding alternatives to *Stylosanthes hamata*, the legume used in fodder banks. Promising alternatives found included accessions of *Chamaecrista rotundifolia*, *Centrosema brasilianum* and *Centrosema pascuorum*. All gave yields comparable to those of *S. hamata* and had high crude-protein contents. Trials were also conducted to screen *Stylosanthes* accessions for tolerance of anthracnose, a fungal disease affecting stylo in more humid areas. Several anthracnose-tolerant accessions were identified.

In the humid zone trials were aimed at identifying suitable accessions of herbaceous forage legumes to supplement the use of the browse legumes *Leucaena leucocephala* and *Gliricidia sepium* as sources of livestock feed. A number of promising accessions were identified, including *Centrosema arenarium*, *C. macrocarpum*, *C. pubescens*, *Desmanthus virgatus*, *Pueraria phaseoloides*, *Stylosanthes guianensis* cv Graham, *S. hamata* cv Verano, *S. scabra* cv Seca and *S. viscosa*.

Studies on the nutritive value of feeds covered not only traditional forages but also crop residues and foliage and seeds of browse trees. A major research area was on identifying polyphenolic compounds in crop residues and browse and determining their effects on feed intake and utilisation. Much of this research was conducted in collaboration with the Institute of Grassland and Animal Production, UK, the University of Reading, UK, the ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Centre, Niger, and the University of Wisconsin-Madison, USA.

One trial examined differences in nutritive value of the crop residues of 12 millet varieties from ICRISAT. The varieties differed significantly in neutral-detergent fibre (NDF) content and in digestibility of NDF of leaf blades, sheaths and stems (Table 23). Lignin content of blades and stems also differed significantly among varieties.

Despite these varietal effects the range in parameters of nutritive value was lower than among sorghum varieties. The range in digestibility of NDF within plant parts of sorghum is greater than 15 percentage points, whereas in the 12 millet varieties it was less than eight percentage points. Millet lacks the phenolic pigments that are largely responsible for differences in NDF digestibility among sorghum varieties.

The nutritive value of the leaf sheath and stem of millet was well below the maintenance requirements of cattle. In Niger farmers usually leave millet crop residue in the field to be grazed by cattle belonging to pastoralists. However, the low nutritive value of leaf sheath and stem indicate that it may not be worth harvesting and storing the crop residue.

Multipurpose trees

Multipurpose trees have considerable potential for use in mixed crop–livestock production systems. They provide high-quality fodder for livestock, fertiliser in the form of mulch, fuel wood, poles and building

Table 23. *The effect of variety on content of neutral-detergent fibre (NDF), digestibility of NDF (DNDF) and content of lignin in leaf blades, leaf sheaths and stems from the crop residue of 12 millet varieties.*

	Mean	Range	Varietal effect
Leaf blade			
NDF (% OM)	59.9	57.7–63.0	**
DNDF (%)	60.1	55.7–62.2	***
Lignin (% OM)	3.9	3.5–4.5	**
Leaf sheath			
NDF (% OM)	69.2	65.5–70.8	**
DNDF (%)	42.4	38.1–44.9	***
Lignin (% OM)	5.1	4.8–5.9	NS
Stem			
NDF (% OM)	76.2	72.5–79.6	**
DNDF (%)	30.7	27.6–35.2	*
Lignin (% OM)	8.7	7.6–9.7	***

* = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$.
OM = organic matter.

timber, shade and shelter from the wind. They also curb soil erosion, conserve moisture, and build up soil fertility. Trees offer advantages over herbaceous species in that they are more persistent, give higher forage yields, are more tolerant of mismanagement and are better able to retain high-quality forage under stress conditions.

ILCA's work on multipurpose trees focused largely on screening accessions for use in highland (Ethiopia), humid (Nigeria) and subhumid conditions (Nigeria and Kenya); testing multipurpose trees (MPTs) in production systems in the same zones; and investigating their nutritive value.

In the humid and subhumid zones the focus of the work was on *Leucaena leucocephala* and *Gliricidia sepium*. In the Ethiopian highlands the preferred species was *Sesbania sesban*. A five-year (1989–94) study was conducted on *Sesbania* species, with investigations of breeding systems and interspecific relations, seed and forage production, and characterisation and classification. Results from these have important implications for the identification and management of *Sesbania* germplasm held by ILCA, which has a collection comprising 410 accessions of 24 *Sesbania* species.

In 1988 and 1989 a trial was conducted at ILCA's Debre Zeit research station to investigate alternatives to *Sesbania sesban* under highland conditions. Nine accessions of five *Leucaena* species (*L. leucocephala, L. diversifolia, L. pallida, L. pulverulenta* and *L. revoluta*) were planted on an Alfisol in August 1988. *Sesbania sesban* (ILCA 10865) was included as the check.

Table 24. *Effect of cutting interval on dry-matter yield in accessions of* Leucaena, *Debre Zeit, Ethiopia, 1989.*

Species	ILCA accession number	Dry-matter yield (kg/ha)			
		First cut in wet season (August 1989)	Following first cut at		
			50 days	86 days	128 days
L. leucocephala	71	296	882	991	536
(cv Peru)	14198	227	230	481	799
"	14200	128	466	399	539
L. diversifolia	11676	447	410	462	624
"	14193	883	547	587	356
L. pallida	14189	1565	593	1187	699
"	14203	2500	504	1240	808
L. pulverulenta	14197	634	411	657	726
L. revoluta	14201	1078	190	661	556
Sesbania sesban	10865	1907	354	460	57

Foliage dry-matter yields were generally low in August, except for accessions of *L. pallida, L. revoluta* and *S. sesban* (Table 24). *Leucaena pallida* ILCA 14203 produced the highest foliage yield. Several accessions had lower yields on day 128, 82 days after the last rainfall, than on day 86, probably due to leaf-drop resulting from soil moisture stress. *Sesbania sesban* was particularly badly affected in this respect.

Sesbania sesban had the highest nitrogen and ash contents, was low in lignin and had the highest *in vitro* dry-matter digestibility (IVDMD). All *Leucaena* accessions had high nitrogen contents and IVDMD values greater than 65%.

Sesbania sesban *hedgerows in the Ethiopian highlands.* Sesbania *accessions showed considerable promise as a multipurpose tree for the highlands.*

Two accessions of *L. pallida* combined good dry-matter yields with high nitrogen content and high digestibility, offering alternatives to *S. sesban* for alley-farming systems at middle to higher altitudes in sub-Saharan Africa.

Subsequent work evaluated the performance of *Leucaena*, *Calliandra calothyrsus* and *Chamaecytisus palmensis* (tagasaste) in replicated trials at Soddo, Ethiopia.

In one trial, 11 selected accessions of *Leucaena* and four accessions of *Calliandra calothyrsus* were planted in rows of 20 plants per row with 0.25 m spacing within rows and 1.5 m between rows in a split-plot design with three replicates and two fertiliser levels (0 and 60 kg P/ha). There were no significant differences in soluble phenolics between species. Applying phosphorus had no significant effect on yield or other growth parameters. Mean leaf dry-matter yields across three harvests ranged from 83 g/tree (a *Leucaena* accession) to 466 g/tree (a *Calliandra* accession). *In vitro* dry-matter digestibility was variable, the four *Calliandra* accessions having the lowest values and *Leucaena leucocephala* accessions the highest.

In a separate trial, eight accessions of *Chamaecytisus palmensis* were established from seedlings at Soddo. There were no significant differences in soluble phenolics between accessions. Mean leaf dry-matter yields across three harvests ranged from 447 to 1224 g/tree, accession ILCA 15378 giving the highest yield. All accessions had an *in vitro* dry-matter digestibility of 60% or greater.

On-farm trials in Ethiopia with selected *Sesbania*, *Leucaena* and tagasaste accessions were started in 1992. *Sesbania* and *Leucaena* accessions were planted at mid-altitude sites at Ginchi (2200 m) and Debre Zeit (1800 m), while *Sesbania* and tagasaste accessions were planted at high-altitude sites at Holetta (2400 m) and Deneba (2600 m). A total of 80 volunteer farmers were involved in the trials. Survival and growth of accessions was generally good in the first year, although at Deneba some *Sesbania* trees died as a result of frost.

At the Kenya coast, work on MPTs focused on developing intensive feed production systems based on growing Napier grass (*Pennisetum purpureum*) in *Leucaena leucocephala* alleys. Trials showed that the two plants were complementary in their rooting habits. *Leucaena* tap roots grew to well below one metre below the soil surface and only 10% by weight of the fine roots were in the top 15 cm of the soil. In contrast, 46% of Napier roots were found in the top 15 cm of soil. The two species thus were not competing for soil nutrients and water in the same soil horizons. However, in 1992, a drought year, large proportions of the Napier plants died. Further trials were planned to investigate alternatives to both *Leucaena*, which is susceptible to attack by psyllids, and Napier.

Assessments of the nutritive value of browses was largely directed at determining the content and effects of polyphenolic compounds in different browse species and accessions. In 1987, for example, a trial showed marked differences between three browse species (*Acacia seyal, A. nilotica* and *Sesbania sesban*).

Leaves from *A. seyal* and *A. nilotica* contained twice as much soluble polyphenolic compounds as *S. sesban* leaves. Leaves from *A. seyal* had the highest content of insoluble proanthocyanidins. Despite these differences, there was no significant difference in the growth rates of sheep fed the different browses as supplements to a teff-straw-based diet (Table 25). There were, however, marked differences in the effects of the browses on nitrogen excretion (Table 25). Apparent and true nitrogen digestibility were significantly lower in the diets containing *A. seyal*, which was the result of a higher faecal excretion of nitrogen. Both neutral-detergent-soluble and neutral-detergent-insoluble nitrogen were higher in sheep and goats fed *A. seyal* than in those fed the other MPT supplements. There were no overall differences in nitrogen balance between the diets because the animals fed *A. seyal* lost less nitrogen in their urine than did animals fed the other supplements.

These results suggested that polyphenolics in *A. seyal* affected protein utilisation by decreasing urinary nitrogen loss and increasing faecal nitrogen loss. The higher excretion of detergent-insoluble nitrogen in the faeces indicated that the proanthocyanidins in *A. seyal* formed indigestible complexes with protein. However, the higher excretion of detergent-soluble nitrogen indicated that polyphenols also increased the excretion of microbial nitrogen, which may originate from endogenous sources.

A follow-up trial was carried out in 1988 to investigate the range of nutritive values and contents of antinutritional substances in a variety of browse species. Leaves and fruits of 86 browse species were collected at Niamey (ICRISAT, Niger), Kaduna (ILCA, Nigeria) and Cotonou (Direction de la recherche agronomique, Benin). Average annual rainfall at the sites was 550, 1050 and 1200 mm, respectively.

Crude-protein content of leaf material ranged from 10 to 38% of DM. Content of soluble phenolics, including tannins, ranged from 6 to 52% of DM. Cell-wall content ranged from 6% of DM in *Acacia nilotica* to 77% of DM in *Vitex doniana*.

True digestibility of DM ranged from 34 to 94%. Digestibility of protein ranged from zero to 88%, and that of fibre from zero to 75%. This variation in digestibility may have been due to the effects of lignin or secondary metabolites such as tannins and other phenolics. There was a high negative correlation between lignin content and digestibility of DM ($r = -0.77$) and fibre ($r = -0.74$). There was also a strong negative correlation between content of soluble polyphenolics and protein digestibility ($r = -0.66$).

In a related study, several Australian *Acacia* species analysed at ILCA were found to have high contents of soluble phenolics, insoluble phenolics, insoluble proanthocyanidins and lignin and very low *in vitro* digestibilities. They were thus of little use as animal feed.

Table 25. *Polyphenolics content in leaves and growth rate, straw intake and parameters of nitrogen utilisation in sheep and goats fed leaves from three multipurpose trees as supplements to teff straw.*

	Acacia seyal	*Acacia nilotica*	*Sesbania sesban*
Soluble phenolics (% DM)	30	34	16
Insoluble proanthocyanidins (A550)	0.552	0.154	0.059
Growth rate (g/day)			
Sheep	40	42	35
Goats	19	17	4
Straw intake (g/day)			
Sheep	422	412	478
Goats	328	348	306
Apparent N digestibility (%)			
Sheep	35	58	51
Goats	44	66	69
True N digestibility (%)			
Sheep	82	92	94
Goats	86	94	94
Faecal detergent-soluble N (% of N intake)			
Sheep	47	33	42
Goats	41	28	25
Faecal detergent-insoluble N (% of N intake)			
Sheep	18	9	6
Goats	14	6	6
Urine N (% of N intake)			
Sheep	18	30	30
Goats	25	35	40
N balance (g/day)			
Sheep	1.6	2.6	2.3
Goats	1.7	1.7	2.6

Also in 1988, ILCA carried out a study to determine the effects of accession, environment, individual tree within an accession and polyphenolic content in *Sesbania sesban* in Ethiopia. Six accessions were selected from evaluation trials at three sites in Ethiopia (Shola, Debre Zeit and Zwai).

Parameters of nutritive value and content of polyphenolic compounds varied widely between accessions and sites (Table 26). Nitrogen and NDF contents, *in vitro* true digestibility and lignin content

Table 26. *Range in components of nutritive value in leaves among six accessions of* Sesbania sesban *and significance of the effect of accession and site.*

	Range	Mean	Accession	Site
Nitrogen (% DM)	2.5–4.6	3.3	0.004	0.001
Neutral-detergent fibre (% DM)	11.3–28.6	17.1	0.001	0.001
In vitro true digestibility (% DM)	81.0–94.1	89.5	0.001	0.009
Lignin (% DM)	0.8–5.3	2.8	0.001	0.001
Soluble phenolics (% DM)	9.3–33.8	17.7	0.001	0.570
Insoluble proanthocyanidins (A55/g NDF)[1]	3–411	46.8	0.001	0.246

1. Absorbance of light with a wavelength of 550 nm.

differed significantly between accessions and sites. Soluble phenolic and insoluble proanthocyanidin contents, averaged across sites, differed significantly between accessions but, averaged across accessions, did not vary significantly from one site to another.

Three of the accessions contained little soluble phenolics and no insoluble proanthocyanidins (absorbance values less than 20). The other three accessions had much higher contents of both types of phenolics, with large variation among trees within accessions. The correlation coefficients for the relationship of *in vitro* true digestibility with lignin, soluble phenolics and insoluble proanthocyanidins were negative and significant (Table 27).

Table 27. *Correlation coefficients between contents of phenolic compounds and* in vitro *true digestibility in leaves from* Sesbania sesban *collected from six accessions at three sites in Ethiopia, 1988.*

	r	P
Lignin (% DM)	-0.57	0.001
Soluble phenolics (% DM)	-0.48	0.001
Insoluble proanthocyanidins (A550/g NDF)	-0.66	0.001

The large differences in nutritive value between accessions was largely related to differences in polyphenolic contents. Polyphenolic compounds have large effects on the availability of protein in browse. When large amounts of polyphenolics are present they complex with protein and reduce its availability. However, low levels of polyphenolics can increase the nutritive value of feed by preventing bloat and improving protein utilisation.

Legume forages in crop–livestock systems

Forage legumes play an important role in developing ecologically sustainable and economically viable livestock production systems. They provide high-quality feed for livestock while at the same time enhancing soil fertility, boosting yields of subsequent food crops. The capacity of legumes to improve soil fertility is particularly important in the fragile environments of sub-Saharan Africa.

Subhumid zone

The best-known example of ILCA's work with forage legumes is the fodder bank, extensively tested in the Nigerian subhumid zone (see Chapter 3, *"Fodder banks,"* pages 53–55, and Chapter 4, *"Subhumid zone,"* pages 122–124). While aimed at providing dry-season feed for livestock, these fodder banks also benefit crop farmers who plant their crops inside the fodder banks. The residual nitrogen built up by the legumes "fertilises" the crops planted inside the fodder bank, increasing yields dramatically (see Chapter 3, *"Fodder-bank management,"* page 55). Details of this are presented under both the Cattle Milk and Meat Thrust and the Small Ruminant Meat and Milk Thrust.

Studies of labour requirements for cropping within fodder banks were initially worrying: they indicated that cropping inside fodder banks required more labour than cropping outside. However, a breakdown of labour needs showed that cultivating land that had been under *Stylosanthes* for several years actually required less labour than cultivating land that had lain fallow. What did require extra labour was harvesting and handling the increased crop yield.

Highlands

Studies in the Ethiopian highlands focused largely on nitrogen fixation by different forage legumes and its effect on subsequent crops (see also Chapter 4, *"Initial evaluation of feed resources,"* pages 143–146), and on intercropping food crops with forage legumes.

Trials in 1988 showed a wide range in the amount of nitrogen fixed by different legumes, with a maximum of nearly 220 kg N fixed per hectare by *Lablab purpureus* cv Rongai compared with less than 50 kg N/ha fixed by *Trifolium steudneri* accessions (Figure 33).

The dry-matter yields of wheat were significantly higher on plots previously planted to the legumes (except *T. steudneri* ILCA D/Z) or fallowed than on plots previously under oats (Table 28). Grain yields were also generally higher on plots following the legumes, although not significantly in the case of the *Trifolium* and snail-medic (*Medicago scutellata*) plots. Fallowing did not significantly affect subsequent wheat grain yield.

Figure 33. *Biological nitrogen fixation by various forage legume species/cultivars grown on an upland soil, Debre Zeit, Ethiopia, 1988.*

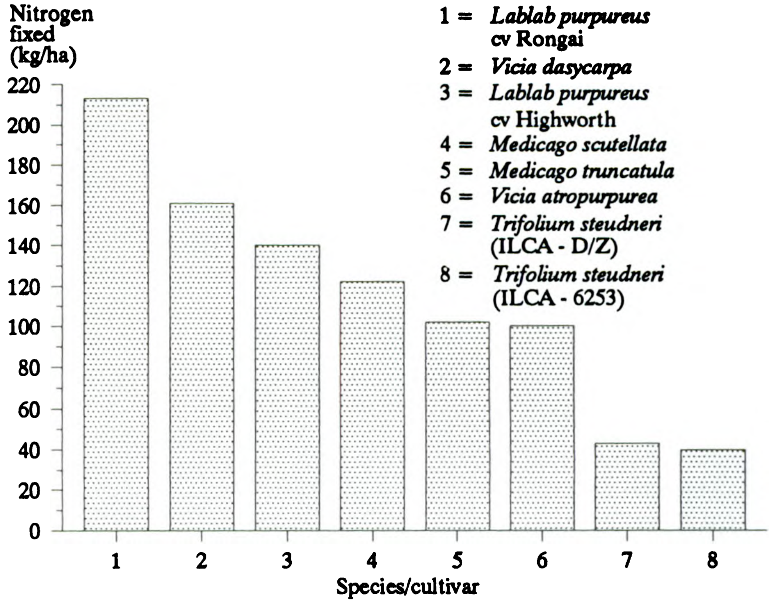


Table 28. *Effect of previous cropping on dry-matter and grain yields of wheat, Debre Zeit, Ethiopia, 1988.*

	Yield (kg/ha)	
Previous crop	Dry matter	Grain
Trifolium steudneri (ILCA D/Z)	2009	861
Trifolium steudneri (ILCA 6253)	2230	995
Vicia dasycarpa	2820	1096
Vicia atropurpurea	2503	1105
Lablab purpureus cv Rongai	2803	1153
Lablab purpureus cv Highworth	2659	1208
Medicago scutellata	2343	1032
Medicago truncatula	2379	1272
Fallow	2269	893
Oats	1790	744

A series of intercropping trials were carried out to determine the effect of intercropping maize with the legume *Macrotyloma axillare* on maize grain yields and feed production. In the first year of the trial, intercropping maize with *Macrotyloma* reduced maize grain yield by 14% when no fertiliser was applied (2882 kg/ha for the intercrop vs 3348 kg/ha for maize in pure stand). Dry-matter yield was increased by intercropping, from 4227 kg/ha for maize alone to 5468 for maize intercropped with *Macrotyloma*. The feeding value of the dry matter was also increased by the inclusion of the legume.

Table 29. *Dry-matter and grain yield of maize and* **Macrotyloma axillare** *cv Archer grown in pure stand or intercropped on an acid soil, Soddo, Ethiopia.*

Cropping system	Dry-matter yield (kg/ha)						Maize grain yield (kg/ha)
	Off-season			Main cropping season			
	9/3/89	17/5/89	Total	Maize	*Macrotyloma*	Total	
Maize				2422		2422	2980
Maize + 60 kg N/ha				2484		2484	3214
Maize:*Macrotyloma*	1970	2503	4474	1173	5122	6296	1351
Maize:*Macrotyloma* + 60 kg N/ha	1936	2223	4141	1005	4357	5362	1164
Macrotyloma	1394	2960	4354		6116	6116	

In the second year of the trial, maize planted into the established *Macrotyloma* yielded less than half as much dry matter and grain as maize planted in pure stand (Table 29). However, the benefit to farmers with livestock of the increased quantity and quality of feed available, especially during the off-season, may be sufficient to compensate for the loss of maize grain yield.

Other trials concerning intercropping cereals with legumes and sequential cropping of forage and food crops were are reported under the Animal Traction Thrust (see Chapter 4, *"Intensified and diversified use of draft animals,"* pages 127–131, Chapter 4).

Trypanotolerance Thrust

The Trypanotolerance Thrust had four major research themes:

- Trypanosomiasis epidemiology
- Trypanotolerance
- Genetics of trypanotolerance
- Biological and economic evaluation of productivity responses to interventions.

Work on these topics was previously reported in Chapter 3 under *"Livestock Productivity and Trypanotolerance Group,"* pages 69–75.

Trypanosomiasis epidemiology

Research under this theme aimed at determining the potential contribution of evaluating parameters relating to the tsetse population to predicting animal health and performance, and evaluating the various factors affecting susceptibility of livestock to trypanosomiasis.

In 1987, analyses of data covering the period from 1984 to 1986 at nine network sites showed a highly significant relationship between estimates of tsetse challenge (the product of relative tsetse density and mean trypanosome infection rates in the tsetse population) and the prevalence of trypanosome infection in livestock ($r = 0.80$; $P<0.0001$).

However, this was not sufficiently sensitive to show meaningful correlations between monthly averages within sites except where major changes occurred. To help refine the estimate of tsetse challenge, samples of tsetse blood meals were taken in 1987 and analysed to determine the flies' feeding behaviour at the different sites.

Species of tsetse are grouped by their morphology and ecological distribution into three subgenera or species groups: *fusca* (subgenus *Austenina*), *palpalis* (subgenus *Nemorhina*) and *morsitans* (subgenus *Glossina*). The preferred habitat of a species has a large influence on its role as a vector of trypanosomiasis to domestic livestock. Thus, although *fusca*-group tsetse flies inhabit vast areas of the forest zones of West and central Africa they have rarely been implicated in outbreaks of trypanosomiasis in domestic livestock because of the relatively sparse population of domestic livestock in these zones. Studies of the blood meals collected at network sites in 1987 enabled a re-examination of the significance of *fusca* group tsetse as vectors of trypanosomiasis to domestic livestock.

Glossina tabaniformis is one of the most widespread species of the *fusca* group of tsetse flies and occurred at three network sites:

- a state ranch of the Office gabonais pour l'amélioration de la production du viande (OGAPROV), Gabon
- a commercial ranch at Mushie in Bandundu District, Zaire; and
- villages in the Idiofa region of central Zaire.

Results from analyses of blood meals taken by *G. tabaniformis* at Mushie ranch, Zaire, indicated that this species will take a considerable proportion of its feeds from cattle when it comes into contact with them (Table 30). At Idiofa, *G. fuscipes*, of the *palpalis* group, took fewer feeds from cattle, suids and humans being the most important hosts for this species. There were too few *G. tabaniformis* flies at this site for collection of suitably-fed flies.

A highly significant relationship ($P<0.001$; $r = 0.892$) was found between tsetse challenge (calculated as the product of the relative density and trypanosome infection rate of the most abundant tsetse species at each site and the percentage of feeds taken from cattle) and trypanosome prevalence in N'Dama cattle over three or four years at the three sites (Figure 34). These analyses indicated that the data gave an accurate indication of tsetse challenge and that at these network sites tsetse species of the *fusca* group were important vectors of trypanosomiasis to cattle.

Table 30. *Results of blood meal analysis for* G. tabaniformis *from Mushie and OGAPROV ranches and* G. fuscipes *from Idiofa, Zaire.*

	G. tabaniformis				*G. fuscipes*	
	Mushie		OGAPROV		Idiofa	
Host species	No.	%	No.	%	No.	%
Cow	58	49.2	3	13.6	7	7.7
Goat	9	7.6	-	-	4	4.4
Sheep	2	1.7	-	-	-	-
Unidentified animal	9	7.6	4	18.2	8	8.8
Domestic pig	9	7.6	-	-	10	11.0
Warthog	3	2.5	4	18.2	17	18.7
Bushpig	15	12.7	4	18.2	7	7.7
Human	8	6.8	3	13.6	35	38.5
Monkey	-	-	-	-	3	3.3
Duiker	4	3.4	4	18.2	-	-
Reptile	1	0.8	-	-	-	-

No. and % refer to identified blood meals.

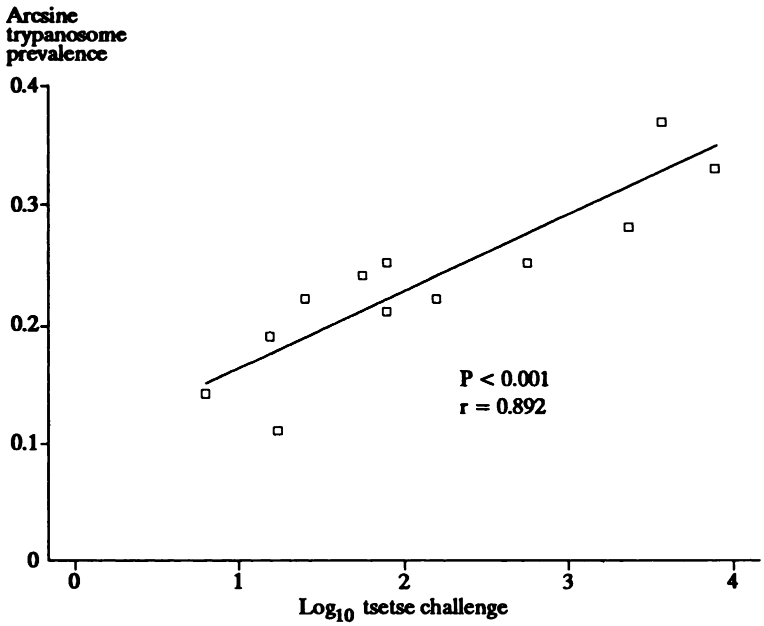


Figure 34. *Relationship between $\log_{10}$ tsetse challenge and arcsine trypanosome prevalence in N'Dama cattle at sites of the African Trypanotolerant Livestock Network with* fusca *group tsetse.*

The usefulness of such "predictive models" of the epidemiology of trypanosomiasis is demonstrated by the example of ILCA's work in the Ghibe valley in Ethiopia.

Starting in 1985, ILCA monitored the occurrence of trypanosomiasis in some 600 Small East African Zebu cattle in village herds in the Ghibe river valley in south-western Ethiopia. Analysis of the data showed that trypanosomes were found repeatedly in the blood of many animals despite their having been treated with the trypanocidal drug, Diminazene aceturate (Berenil). The proportion of animals infected was increasing, and appeared to be higher than expected given the degree of tsetse challenge in the area. Taken together, these signs suggested that the efficacy of the trypanocidal drug was decreasing.

By 1989, in any one month over 30% of the cattle were found to be infected with *Trypanosoma congolense*, the predominant trypanosome in the Ghibe area. Re-analysing the data to pick up only new infections — taking into account only those animals that had been free of the disease for the previous two months — showed a "new infection" rate of less than 20%. The difference between this value and 30% was taken as an indication of the level of recurrent infection. Thus, over one-third of the animals infected with *T. congolense* were suffering from recurrent infections, i.e. infections that had not been cleared by drug treatment.

Samples of *T. congolense* from Ghibe tested at the International Laboratory for Research on Animal Diseases (ILRAD) showed clear evidence of a build up of drug resistance. Of 12 isolates tested, all showed a high prevalence of trypanosomes resistant to Berenil and homidium chloride, another common trypanocidal drug. All but one showed a high proportion of trypanosomes resistant to a third commonly used trypanocidal drug, isometamidium chloride.

These results are a portent of what is likely to become an increasingly serious problem. They underscored the urgent need to seek alternatives

Non-trypanotolerant zebu cattle grazing in the Ghibe river valley, Ethiopia. Studies indicated the build-up of drug resistance in strains of trypano somes from this area.

to drug therapy as a means of maintaining livestock in tsetse-infested areas, pointing to an increasing role for trypanotolerant livestock.

Another important finding in the field of trypanosomiasis epidemiology was the marked difference in the effects of *T. congolense* and *T. vivax* infections on animal performance. This was first indicated in a 1991 trial in Gabon which used antigen detection enzyme immunoassay (ELISA) tests developed by ILRAD to diagnose and differentiate between the two trypanosome species. In 1992 health and production data recorded on N'Dama cattle in Zaire over the five years from 1986 to 1991 were analysed based on these findings. Although the Zaire trials used traditional microscopic techniques to identify the trypanosome species, the data are unique because of the long period of continuous recording, the large number of occasions on which samples were taken from each animal, the very high percentage of animals infected and the approximately equal proportions of *T. vivax* and *T. congolense* infections detected.

One month after weaning (i.e. at 11 months old) animals were equally infected with *T. vivax* and *T. congolense*. From this age onwards, there was a very gradual decrease in the proportion of time a weaned calf was infected with *T. vivax*. This decline continued up to the oldest age recorded, 42 months. Over this period, the proportion of time an animal was infected with *T. congolense* did not decline (Figure 35).

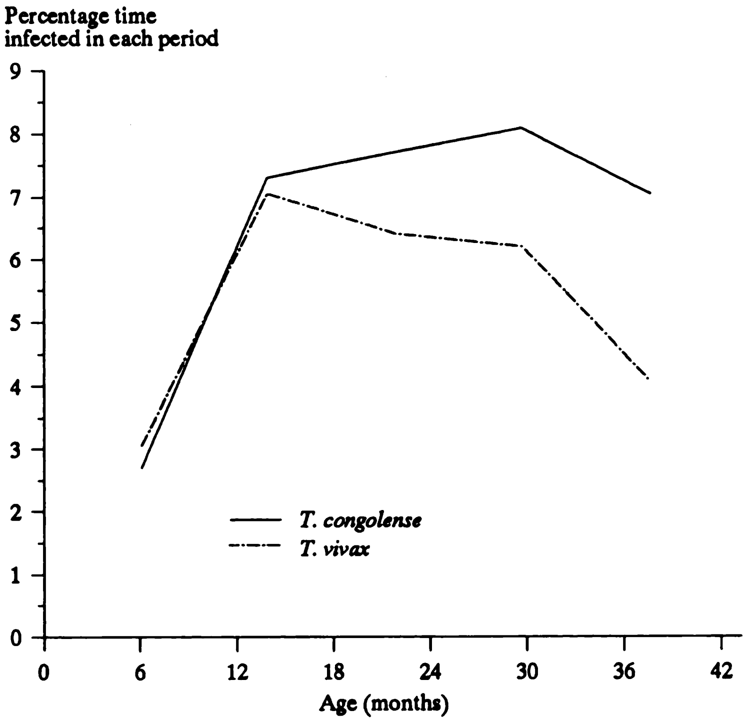
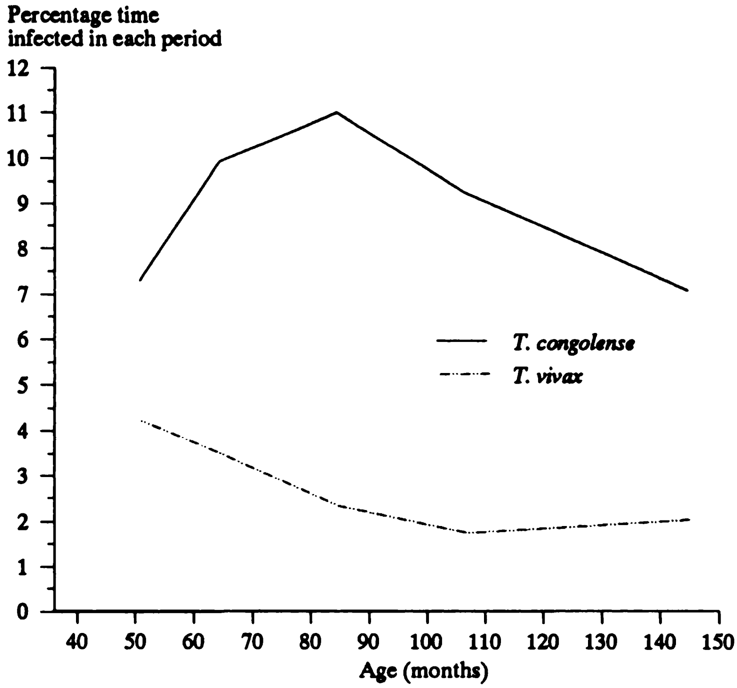


Figure 35. *Percentage of time infected with* T. vivax *and* T. congolense *in animals from birth to 42 months of age.*

Figure 36. *Percentage of time infected with* T. vivax *and* T. congolense *in animals from 40 to 150 months of age.*



Data from the dams of these animals showed that this gradual decrease in the proportion of time an animal was infected with *T. vivax* continued from four years to at least eight years of age (Figure 36). Again, over this period the proportion of time a cow was infected with *T. congolense* did not decline. Thus, while at 11 months old there was equal infection with *T. vivax* and *T. congolense*, by eight years of age *T. vivax* infection was only one-third that of *T. congolense* infection. Evidently, N'Dama cattle in this region of Africa acquire some control over the development of parasitaemia following *T. vivax* infection, but apparently cannot control *T. congolense* infection.

Unweaned calves grazing with their dams appeared to have some protection from, or to be more resistant to, both *T. vivax* and *T. congolense* infections than were their dams or than they were themselves immediately after weaning.

The level of *T. congolense* infection in calves before weaning was only one-third of that in their dams. In contrast, the level of *T. vivax* infection in unweaned calves was the same as that in their dams, which had had an average of eight years over which to acquire ability to control the effects of *T. vivax* infection. The question of whether the calves were for some reason less exposed to the risk of infection or whether there is such a phenomenon as age resistance requires further investigation. It was thought unlikely that colostrum had any significant effect as weaning did not occur until around 10 months of age, long after colostrum absorption has ceased.

Trypanotolerance

Work under this theme was aimed at assembling information on the health and productivity of trypanotolerant and susceptible livestock breeds and their crosses in different agro-ecological zones and management systems, and under different levels of quantified tsetse challenge. One of the main objectives was to identify criteria measuring levels of trypanotolerance. Major constraints to putting genetic resistance to trypanosomiasis to practical use were related to difficulties in the definition and measurement of criteria of trypanotolerance. Previous studies concluded that the abilities to resist anaemia and to control parasitaemia are key indicators of the trypanotolerance trait and these processes, although controlled genetically, are not necessarily directly linked to each other.

Work carried out in Gabon in 1991 indicated that the control of parasitaemia, as measured by new trypanosome antigen-detection techniques combined with more traditional microscopic diagnostic methods, showed great possibility as a reliable measurement of trypanotolerance.

In 1992, analysis of health and production data from Zaire covering the five years from 1986 to 1991 quantified the effects of aspects of trypanotolerance on an animal's requirement for trypanocidal drug treatment and on its post-weaning growth.

Four parameters regarded as indicators of trypanotolerance (species of trypanosomes detected, length of time parasitaemic, parasitaemia score and anaemic condition as estimated by PCV values) were measured on animals over the two years following weaning at 10 months old. The relative effects of changes in these indicators on trypanocidal drug requirements and growth were assessed. The effects of species of trypanosome on drug requirements and growth were directly measurable. In the case of the other three indicators, the effects on drug requirements and growth that would be caused by a change of one standard deviation in each were calculated. This allowed comparison of similar-sized changes in these three indicators that are of necessity recorded in dissimilar units.

Trypanosoma vivax and *T. congolense* infections had similar effects on number of trypanocidal drug treatments required, an average of 0.61 treatments being administered to each infected post-weaner. A reduction of one standard deviation in length of time infected reduced the number of treatments required by 0.23 or 36%; a reduction of one standard deviation in parasitaemia core reduced the number of treatments required by 0.06 or 10%; and an increase of one standard deviation in PCV reduced the number of treatments required by 0.27 or 43%.

A *T. congolense* infection reduced growth by 12.4 g/day or 8% more than a *T. vivax* infection. A reduction of one standard deviation in length of time infected increased growth by 9.8 g/day or 6.5%; a reduction of one standard deviation in parasitaemia score increased growth by 9.0 g/day or 6.0%; and an increase of one standard deviation in average PCV increased growth by 8.4 g/day or 5.6%.

Thus, changes in trypanosome species, length of time parasitaemic, intensity of parasitaemia and average PCV each have approximately equal effects on daily liveweight gain. Absence of information on any of these criteria would significantly affect the accuracy of the estimate of an animal's trypanotolerance and reduce the progress possible in production projects involving N'Dama cattle.

In a further study, in 1991, data from two network sites, Mushie Ranch in Zaire and OGAPROV Ranch in Gabon, were analysed to elucidate the effects of trypanosome infections on reproductive performance.

At Mushie Ranch, scientists recorded data each month on a variety of health aspects, including PCV and occurrence of parasitaemia. They also monitored the reproductive performance of the same animals — in particular the time they take to conceive again after calving — throughout their productive lives. Preliminary analyses in 1991 covered 186 cows and their progeny monitored between 1984 and 1990. Monthly records on the cows covered an average of five years. Over this period the cows had completed a total of 436 calving intervals.

A total of 1028 cow-year records were available from OGAPROV Ranch in 1991. These records were for 260 N'Dama cows, each of which had matching health and production records covering at least two years. In addition, 458 records covered calf-dam pairs in which the calf had survived to weaning, and for which monthly health and production records were available for both the cow and the calf and the dam had weaned at least two calves.

The results from both sites showed a clear link between an animal's level of trypanotolerance — as indicated by high PCVs when infected — and its reproductive performance.

In Zaire, animals able to maintain high PCVs had shorter calving intervals than those with low PCVs. Among cows infected twice by *T. congolense* in the eight months after they had calved, time to conception decreased significantly by 15.3 days with each percentage-point increase in PCV.

In Gabon, calf weaning weights increased by 0.90 ± 0.39 kg for each percentage-point increase in average calf PCV and by 0.96 ± 0.39 kg for each percentage-point increase in average cow PCV. Calving rate increased by $3.3 \pm 0.65\%$ with each percentage-point increase in average cow PCV.

The number and species of trypanosome infections also had a marked effect on animal responses at both sites. In Zaire, trypanosome infection had a significant effect on time to conception only when cows were infected twice with *T. congolense* in the eight months after calving. Single *T. congolense* or *T. vivax* infections had no significant effects on time to conception. Cows infected twice with *T. congolense* conceived again nearly two months later than cows that remained free from trypanosomes (212 ± 22.4 vs 156 ± 16.1 days). In Gabon, only *T. congolense* had a significant effect on calving rate. *Trypanosoma vivax* infections did reduce calf weaning weight, but by less than *T. congolense* infections.

These results were the first to demonstrate the magnitude of the effects of trypanosome infections on reproductive performance under high natural trypanosomiasis challenge. They again demonstrated the benefits of trypanotolerant cattle in tsetse-infested areas, not only in terms of short-term productivity, such as weight gain, but also through their greater life-time productivity.

Genetics of trypanotolerance

Genetic parameters of measures of control of anaemia were evaluated for the first time in field tests in 1989. A total of 148 one-year-old N'Dama cattle, progeny of 29 sires, were exposed for 92 days to a medium level of natural tsetse-trypanosome challenge at OGAPROV Ranch, Gabon. Matching health and performance data were recorded on 11 occasions. Average PCV and lowest PCV reached during the period were taken as measures of ability to control the development of anaemia. Attempts were made to systematically control other possible causes of anaemia.

In animals which were detected as being parasitaemic, those with above-average average PCV values or above-average values for lowest PCV reached had weight gains that were respectively 34 and 35% greater than the weight gain of animals with below-average values for each measure. Even when not detected as parasitaemic, animals with above-average average PCV or above-average lowest PCV reached had weight gains that were respectively 14 and 12% greater than that of animals with below-average values, indicating that some of the apparently non-parasitaemic animals were in fact parasitaemic.

The heritabilities of, and genetic and phenotypic correlations between, growth, average PCV and lowest PCV reached on test are shown in Table 31.

The heritability of body weight at the start of the test, when animals were approximately 50 weeks old, was 0.49. This was within the normally reported range for this trait, while the large standard error may have been a reflection of the small number of progeny per sire. When all environmental and parasitaemia information was taken into account, the

Table 31. *Heritabilities of, and genetic and phenotypic correlations between, growth, average packed cell volume (PCV) and lowest PCV reached on test.*

	Growth	Average PCV	Lowest PCV reached
Parasitaemia detection and parasitaemia score not included in the analysis			
Growth	0.22 ± 0.28	0.41 ± 0.73	-0.13 ± 0.74
Average PCV	0.35	0.35 ± 0.30	0.96 ± 0.20
Lowest PCV reached	0.29	0.72	0.48 ± 0.31
Parasitaemia detection included in the analysis			
Growth	0.38 ± 0.30	0.71 ± 0.42	0.28 ± 0.55
Average PCV	0.32	0.63 ± 0.33	0.99 ± 0.17
Lowest PCV reached	0.25	0.66	0.51 ± 0.32
Parasitaemia detection and parasitaemia score included in the analysis			
Growth	0.39 ± 0.31	0.70 ± 0.42	0.28 ± 0.55
Average PCV	0.32	0.64 ± 0.33	1.00 ± 0.17
Lowest PCV reached	0.25	0.67	0.50 ± 0.32

± SE
Heritability is the value on the diagonal.
Genetic correlation is the value above the diagonal.
Phenotypic correlation is the value below the diagonal.

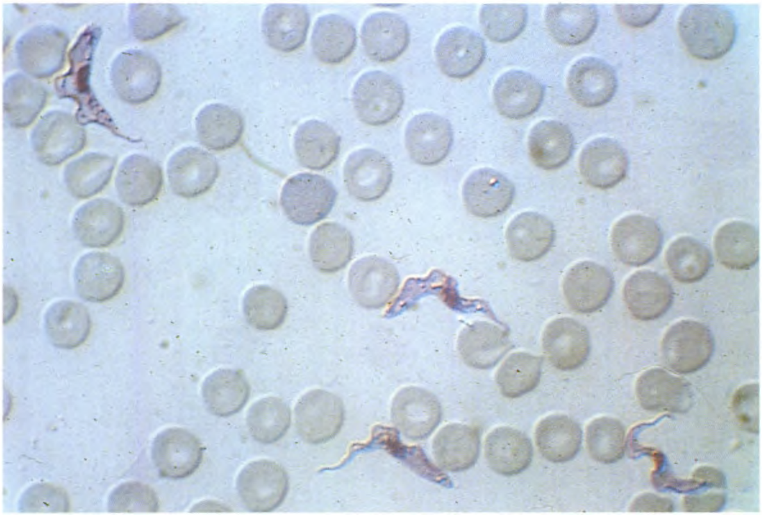
heritability of growth over the rest of the test period was 0.39, again within the expected range for growth over a three-month period.

The heritabilities of both PCV measures were higher than the corresponding heritability of growth in all analyses and were 0.64 and 0.50 when all environmental and parasitaemia information was used.

When all environmental and parasitaemia information was taken into account, the genetic correlation between average PCV and growth was 0.70 and between lowest PCV reached and growth, 0.28. These values, coupled with the higher heritabilities of the PCV measures, indicated some possibility of selection on PCV values for control of anaemia development.

Both heritability and genetic correlation values increased when parasitaemia information was included in the analysis, although parasitaemia was detected in only 28% of the animals. The differences observed between non-parasitaemic animals with high PCV values and those with low PCV values indicated that not all cases of infection were being detected.

In 1990 this problem was overcome by using an antigen-trapping monoclonal-antibody-based ELISA test for trypanosomes, which had been developed by ILRAD. This test demonstrates the presence of trypanosome antigens in the blood, an indication of infection. Animals that tested positive with the ELISA test but exhibited no trypanosomes by the parasitological test were termed "antigenaemic". This was taken



Trypanosomes in the blood. New tests developed by ILRAD provide a more accurate indication of trypanosome infection.

as a sign that the animal was better able to control parasite development than an animal in which trypanosomes were found.

Using this test in a trial at OGAPROV showed that parasitaemic animals had significantly lower average PCV and daily weight gain than antigenaemic animals. There were no differences in these characters between antigenaemic and non-infected animals. The trial gave a heritability estimate for parasite control of 1.08, compared with 0.33 for growth and 0.57 for average PCV. The ELISA test thus offered, for the first time, a practical means of identifying animals with a superior ability to control parasitaemia, providing the opportunity for selection based on this criterion as well as on that of anaemia control.

Further tests at OGAPROV Ranch indicated that the effects on growth rate of ability to control anaemia were similar in both antigenaemic and parasitaemic animals. This suggested that it may be possible to select on the basis of PCV in antigenaemic animals as well as in parasitaemic animals. This would be a major benefit because it would allow selection to be carried out in areas where trypanosome challenge is less severe.

Biological and economic evaluation of productivity responses to interventions

The objective of work under this theme was to evaluate the usefulness and economic viability of interventions developed under the other themes.

Economic evaluation

An example of this was the economic evaluation of the introduction of N'Dama cattle for beef production in the Idiofa region of Zaire. This was the first study of its kind to be based on complete economic data and recorded productivity. It provided first-hand information on the economic feasibility of introducing trypanotolerant cattle into village systems in tsetse-infested areas where cattle husbandry has not been practised in the past. Herd structures and mean productivity values were derived for 18 herds monitored from January 1986 to December 1989. Economic data were obtained in May 1989.

The study used cost-benefit analysis involving a herd-simulation model to take into account the dynamics of livestock production. A society-level economic analysis was performed and profitability was looked at from the point of view of the society as a whole. An individual-level financial analysis was also carried out to complement the society-level economic analysis.

The society-level economic analysis showed an overall net benefit investment ratio of 1.11, using a 10% discount rate, and an internal rate of 11.7%. The individual-level financial analysis revealed a net benefit investment ratio of 1.22 and an internal rate of return of 13.4%. In both cases the returns were positive but not outstanding.

The study showed that in spite of reasonable cattle productivity and low inputs the economic and financial returns were limited. Two factors that contributed to this were, first, the relatively high cost of purchase of breeding animals brought about by the shortage of cattle available for purchase in the Idiofa region and, second, the high cost of beef relative to the purchasing power of the local population. Nevertheless, the case study provided clear indications of the economic feasibility of introducing trypanotolerant cattle in villages where cattle husbandry has not been practised in the past.

Biological evaluation

A series of studies in The Gambia demonstrated that better feeding helps trypanotolerant cattle reduce the effects of trypanosome infections.

In 1990, a group of N'Dama bulls infected with *T. congolense* were fed either well or poorly and their response to the disease was monitored. All the animals became increasingly anaemic once the parasites appeared in the blood: PCV levels declined linearly, reaching a minimum 24 days later. But feeding level had a marked effect on both how fast and how far PCV fell. PCV fell significantly more slowly in well-fed animals than in poorly-fed animals (0.199 cv 0.273 units per day; $P<0.01$). Well-fed animals also maintained a higher level of PCV during the four weeks after the initial decline in PCV had halted (21.1 cv 19.8%; $P<0.01$).

In 1991, results from a series of feeding trials were collated and analysed. These clearly demonstrated that, while supplementing the diets of heifers and lactating cows was worthwhile, the effects of supplementary feeding on calf performance were small and only temporary.

The results showed that the lifetime reproductive performance of N'Dama cows can be raised by feeding heifers better for a short period. Supplementing N'Dama heifers grazing natural pastures with groundnut cake during the late dry season and early wet season markedly increased weight gain during both the dry and the wet season and significantly increased conception rates and subsequent calving rates. Together, these effects mean that heifers may calve up to a year earlier than they might have if not supplemented. Groundnut cake is readily available in The Gambia and supplementary feeding is both practical and economically sustainable.

Supplementing the diets of lactating cows in the village system had large benefits for milk production and reproductive performance. In a series of trials in three villages, feeding cows 1 kg of cottonseed a day in addition to normal grazing during the dry season increased milk offtake for human consumption by 63%, from 52.8 to 86.1 litres, and reduced cow weight losses by 40%, from 34.8 to 24.9 kg.

In a second set of trials, cows fed 90 kg of sesame seed cake over the dry season — either 1 kg a day from January to March, or 1 kg a day from April to June, or 0.5 kg a day from January to June — performed better then unsupplemented cows, irrespective of the supplementation scheme. Supplementation increased milk offtake by 70% (from 69 to 121 litres), reduced cow liveweight losses by 34% (from 41.8 to 27.4 kg) and increased calf weight gain by 90% (from 13.9 to 26.3 kg). Providing the supplement at the lower rate over six months gave the best results; 64% of cows on this feeding regime calved again within two years, while only 19% of unsupplemented cows did so.

The combined results of the oilseed feeding trials showed that each kilogram of supplementary crude protein fed produced an extra kilogram of milk and an extra 250 g of calf live weight and reduced cow liveweight losses by 380 g.

Livestock Policy and Resource Use Thrust

This thrust had five major themes:

- Policy services
- Policy research
- Range trends
- The role of livestock in semi-arid farming systems
- Resource services.

Policy services

The main foci of this theme were information exchange and training. The primary medium of information exchange was the African Livestock

Policy Analysis Network. This grew out of the Livestock Policy Analysis Conference convened by ILCA in 1984 and consisted of a series of newsletters and "network papers" designed to share information and experiences among livestock policy analysts in Africa.

The Section also offered training courses in policy analysis annually, alternately in English and French.

Also coming out of this theme, in 1991 ILCA published *A Handbook of African Livestock Statistics* as part of the Centre's effort to provide African policy makers with the information they need. The Handbook provides data on:

- livestock populations and their changes
- meat and milk production
- trade in livestock products
- consumption and food supply
- prices
- animal health services, and
- land, human populations and economic factors.

The Handbook brought together for the first time, in a direct and usable form, information that is otherwise dispersed among a wide range of sources and hence difficult to gather and use. It serves as a practical data base that is of use to planners, analysts and policy makers in African NARS and international and donor organisations concerned with the performance of the livestock sector in Africa.

The data in the Handbook offer some cause for concern. For example, growth rate in cattle populations showed a marked decline between 1961–74 and 1975–87, falling from 1.8 to 1.3% a year for sub-Saharan Africa as a whole. Annual growth rate in average milk yields per cow milked changed little over the period (1.1 and 1.2% a year), with an average yield of only 300 kg per cow in 1987 — less than half the average for the developing world as a whole (754 kg).

Overall, the message that emerges from the statistics is that there is room for substantial increases in livestock productivity in sub-Saharan Africa. Productivity levels are much lower in sub-Saharan Africa than in other parts of the world and are growing only slowly, if at all. Coupled with Africa's rapidly rising human population, this means that livestock production per person is falling. Urgent efforts are needed to boost production, and better policies are a key element in this effort.

Policy research

Two major areas of policy research carried out by ILCA under this theme covered the impact of livestock pricing policies on meat and milk production in selected countries of sub-Saharan Africa, and land tenure and trees in West Africa.

Livestock pricing policies

Livestock pricing policies in countries of sub-Saharan Africa are important in three main respects. First, many of the rural people in these countries derive their livelihood from livestock production and their incomes are directly related to the prices they get for the commodities they produce. Second, prices represent a cost to consumers who spend an important part of their income on livestock products. Third, livestock pricing policies are important to governments because of their implications for producer incentives, and for government revenue and expenditure.

Because of these different and contradictory functions of prices, most governments are unwilling to leave the determination of prices to market forces and instead try to control the effects of prices through a variety of institutional interventions. ILCA's study aimed at:

- comparing the objectives and instruments of livestock pricing policies in selected countries in sub-Saharan Africa (Côte d'Ivoire, Mali, Nigeria, Sudan and Zimbabwe)
- estimating the effects of direct and indirect interventions on producer incentives, livestock output and consumer welfare.

The study, which covered the period from 1970 to 1986, found that national livestock policies had numerous objectives and employed a variety of policy instruments. Objectives included increased self-sufficiency in meat and milk, promotion of exports, stabilisation and control of inflation, generation of revenue for the government, improved nutrition and provision of employment opportunities.

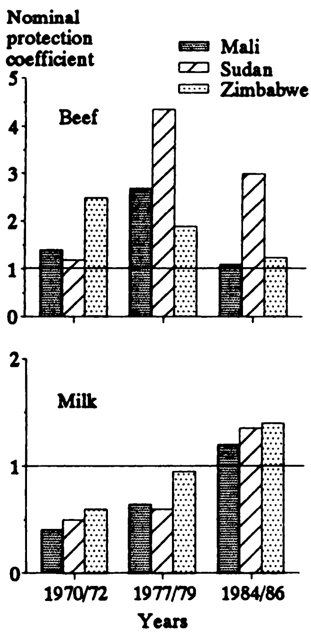
Self-sufficiency was the most common objective. Unfortunately, production and consumption trends and self-sufficiency ratios (the ratio of domestic production to total consumption) show that this objective eluded the countries studied for most of the period covered by the study. Consumption of milk, in particular, increased faster than production in all five countries between 1971 and 1985.

The policy instruments used included controlled prices, input subsidies, trade taxes, consumer subsidies, import licences and foreign exchange allocations.

Zimbabwe made extensive use of controlled prices. These were administered by two parastatals, the Cold Storage Commission and the Dairy Marketing Board, which purchased meat and milk respectively from producers. Consumer prices, particularly of beef, were subsidised by the government. In contrast, Côte d'Ivoire used input subsidies to reduce producers' costs of production. This instrument was used to encourage producers to adopt modern technologies, including improved feeds and veterinary drugs.

1. The nominal protection coefficient (NPC) provides an indication of the taxation or subsidisation rate on producers, and hence of the degree of distortion affecting the market. An NPC of 1.0 indicates that producers are receiving prices equivalent to world-market prices and are being neither taxed nor subsidised. An NPC of greater than 1.0 suggests that producers are being subsidised and consumers taxed, while a ratio less than 1.0 indicates a tax on production and a subsidy for consumption.

Figure 37. *Price policies in study countries implicitly subsidised beef production, but in Mali, Sudan and Zimbabwe milk producers were taxed for most of the study period.*



The study highlighted the multiple objectives of policies affecting the livestock sector, many of which conflicted with each other. For example, in most of the countries, policies were in force with the objectives of both providing producer price incentives and stabilising or reducing consumer prices.

On balance, real producer prices increased over the study period, i.e. nominal prices increased faster than the cost of living. The nominal protection coefficient[1] — the ratio of domestic producer price to the border equivalent price — indicated that policies in the study countries implicitly subsidised beef production over the period studied, although in Mali, Sudan and Zimbabwe milk producers were implicitly taxed for most of the study period (Figure 37).

Except in the cases of beef in Côte d'Ivoire and Zimbabwe and milk in Mali, there was a gradual shift from consumer subsidisation to taxation during the study period.

Official exchange rates were used to estimate nominal protection coefficients. Since official exchange rates in Africa often overvalue the national currency, the results may overstate the actual levels of consumer taxation and producer subsidisation. The analysis thus demonstrated the important implications of exchange rates for domestic pricing policies and highlighted the need to address exchange-rate distortions at the same time as tackling direct price distortions.

A calculation of the costs and benefits of the policies followed by the countries studied indicated marked effects on production and consumption. The most striking case was that of milk in Mali. The analysis indicated that the "negative protection" of milk production between 1970 and 1972 reduced domestic production by 208 000 tonnes and increased consumption by 36 000 tonnes. Thus, in effect the policies could have increased imports by 244 000 tonnes. Mali actually imported a total of only 13 000 tonnes of milk during this period. Hence, had policies not distorted prices, Mali might well have become more than self-sufficient in milk. Social costs — earnings forgone as a result of suboptimal policies — ranged in 1984–86 from US$ 1.1 million for Zimbabwe to US$ 416 million for Nigeria.

Land tenure and alley farming

Another aspect of the policy environment that markedly influences adoption of technology is the control farmers have over their "factors of production" — including their rights and obligations under the prevailing land tenure system.

Unclear land tenure discourages farmers from adopting technologies that provide long-term benefit if the benefit is tied to a piece of land. An example of such a technology is alley farming. Planting trees is a long-term investment, with the benefits to soil fertility becoming apparent only over several years.

In 1989, the Land Tenure Center (LTC) of the University of Wisconsin-Madison, in collaboration with ILCA, started a study of land tenure systems in Cameroon, Nigeria and Togo. Surveys were carried out in each country by national scientists, with assistance from LTC and ILCA staff. The survey in Nigeria covered areas where ILCA and the International Institute of Tropical Agriculture (IITA) had already conducted on-farm research on alley farming and involved 84 alley farmers, 49 ex-alley farmers and 107 conventional farmers. The surveys in Cameroon and Togo included only a few alley farmers, because the system had been less widely introduced there.

The surveys showed that farmers acquire land through various means, including purchase or being given land (5–10% of fields in each country), divided inheritance[2] (half the fields in Cameroon and Nigeria, a quarter in Togo) and undivided inheritance[3] (a third of all fields in each country). Secondary access[4] was important in Togo, particularly where land was scarce.

2. Divided inheritance: land that is divided among the heirs, giving each full control over their own parcel of land.

3. Undivided inheritance: land that passes to the heirs collectively, with the result that no one person has absolute control over any part of the land.

4. Secondary access: generally implies land obtained through a rental agreement, pledge or loan.

The relationship between land tenure and the uptake of alley farming was established by comparing farmers who continued alley farming, those who began alley farming but stopped and those who had never adopted alley farming.

Most of the continuing alley farmers had obtained their land through divided inheritance. In contrast, most farmers who had not adopted alley farming, and those who had stopped, had land obtained through undivided inheritance. In Nigeria, 70% of alley farmers' fields were held under divided inheritance, while 60% of ex-alley farmers' fields were held under undivided inheritance.

Characteristics associated with divided inheritance land included:

- a higher incidence of tree planting than on other types of land
- a higher incidence of commercial and fruit trees
- greater use of inputs to enhance soil fertility
- better soil fertility
- closer proximity to the homestead
- more frequent fallowing.

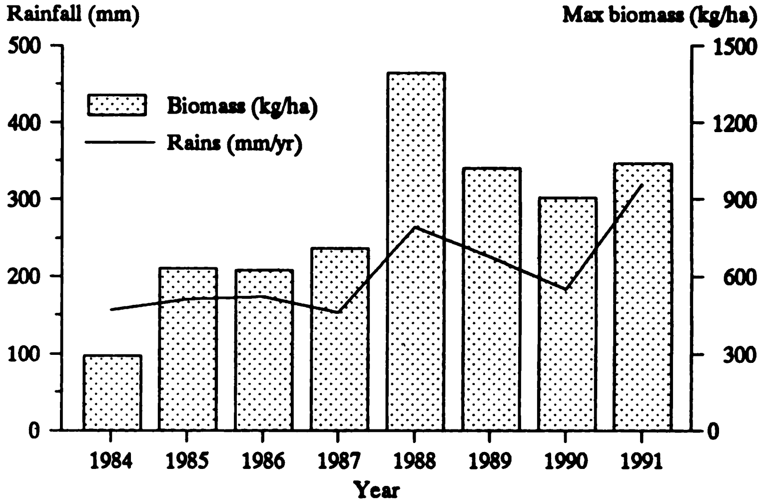
Farmers thus appeared willing to invest more in land obtained under divided inheritance than in land held under other types of tenure. Apparently, their greater security of tenure made them more likely to take a longer-term view, since they could expect to be the principal beneficiaries of any investments they made.

Range trends

Research under this theme focused on long-term monitoring of rangeland productivity in the Gourma region of Mali (see also Chapter 3, *"Monitoring range resources,"* pages 59–61). ILCA scientists monitored rangeland productivity at some 25 sites in the Gourma region from 1984 until 1993. Information was collected on above-ground biomass yield, plant cover and species composition, together with rainfall data.

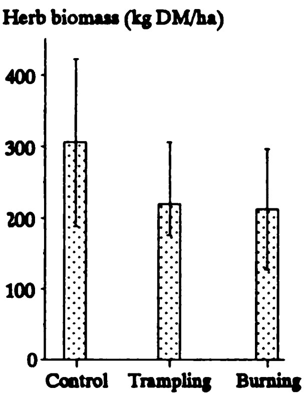
Between 1984 and 1991, annual rainfall fluctuated widely, from a minimum of 158 mm (averaged across 24 sites) in 1987 to 326 mm in 1991 (Figure 38). During this period, annual biomass yields closely followed annual rainfall (Figure 38), even after the exteuded drought, demonstrating the resilience of the Sahelian rangelands.

Figure 38. *Biomass yield closely follows annual rainfall in the Sahelian zone.*



The effects of livestock and human pressure in the dry season — such as grazing, trampling and burning — or during the growing season — e.g. heavy grazing — carry over into the following growing season. Trials were carried out in 1990 and 1991 at three sites to examine what effect trampling and burning the vegetation during the dry season would have on biomass yield in the following rainy season.

Figure 39. *Trampling and burning appear to reduce range yields but high variability masks the significance of the effect.*



The trends observed were as might be expected. Yields in the following season were lower following trampling, and lower still following burning, than on the protected control plots, but the differences were not significant (Figure 39).

A third treatment — short-duration grazing — was applied to plots adjacent to the trial at two contrasting sites, one an upland site (site 31) and one in a depression, which benefited from "run-on" water during the rainy season (site 20).

Again, trends were apparent in plant density and total plant cover. Both were lower in burned and grazed plot than in control and trampled plots. The effects of the treatments appeared to be larger on the upland site, where the vegetation was dominated by forbs, than on the "depression" site, where the vegetation was primarily grasses (Figure 40). On the upland site, grass density seemed to increase following

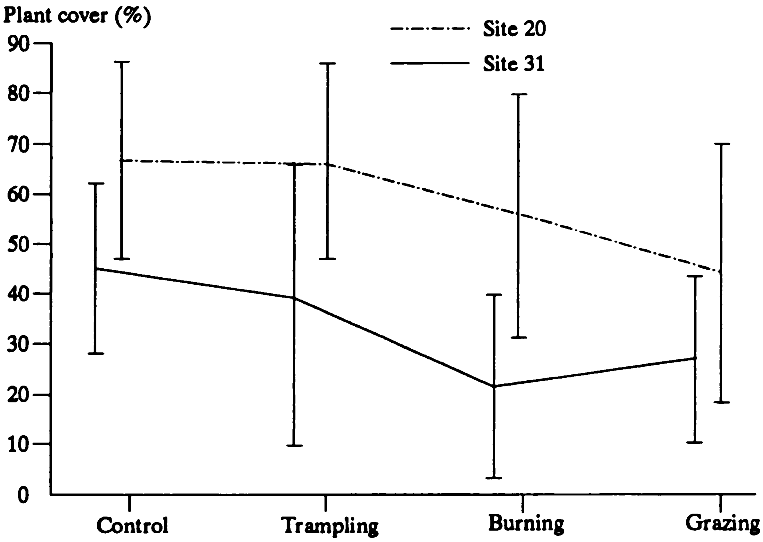


Figure 40. *Trampling, burning and grazing all appeared to reduce plant cover, especially where the predominant vegetation was broad-leaved plants.*

burning, trampling and grazing as compared with the protected control plots.

Despite the large differences between treatment means, there were no significant differences between the treatments. This reflects the enormous variability inherent in the Sahelian rangelands and highlights one of the main difficulties in studying range trends and land degradation.

Related studies investigated the mechanisms that have allowed the pasture grass, *Cenchrus biflorus*, to colonise large areas of sandy soils in the Sahelian rangelands over the long period of below-average rainfall since the late 1960s. In many parts of the Sahel, *Cenchrus* now accounts for as much as 80% of the herbage biomass.

During the rainy seasons from 1987 to 1989, an 0.1 hectare plot of a range-type dominated by *C. biflorus* was subjected to light grazing and repeated cutting as the grass was flowering. This prevented effective flowering and drastically reduced seed set. Another 0.1 hectare plot was subjected to light grazing only. In 1991 the yield and species composition of both plots were examined.

The results demonstrated the superb adaptation of *Cenchrus biflorus* to its environment. The grass produces an extremely spiky seed head that livestock find unpalatable, leaving it alone until the seeds have dropped. Under normal conditions, the grass is able to seed profusely, rapidly building up the stock of its seed in the soil.

Removing the plant's grazing defence mechanism — its spiky seed head — rapidly reduced its dominance in the pasture. In the repeatedly-cut plot, *Cenchrus* produced a plant cover of only 5%, compared with 16% cover in the uncut plot. However, the biomass yields of the two plots were not significantly affected, the place of *Cenchrus* being taken by other grasses and forbs. Another characteristic of *Cenchrus* is its profuse tillering, rapidly establishing ground cover when conditions are favourable.

The spiky seed heads of *Cenchrus* make it effectively inedible for about four weeks at the height of the growing season. This coincides with a period of relative plenty in the rangelands, when grazing pressure is low. Although other plants may become the focus of increased grazing attention while *Cenchrus* flowers, many species have already completed their growth cycle by this time and are thus better able to tolerate grazing than they would be during other periods. *Cenchrus* thus helps maintain the resilience of the rangelands, protecting the soil during the rainy season and avoiding the worst effects of overgrazing.

These studies revealed a picture of ecosystems that are both more dynamic and more resilient than had often been assumed. Rangeland "degradation" is not a one-way process that can be determined from observations at isolated points in time. Rather, there is a process of constant change. Less palatable, unproductive plants may supplant palatable, more productive species for a time, but in doing so they may protect remaining reservoirs of seeds of the palatable species. In time, the more productive species may be able to re-establish themselves earlier than they might have if they had been subjected to continued grazing pressure.

Cenchrus biflorus*-dominated range in the Gourma region of Mali.*

The role of livestock in semi-arid farming systems

The central focus of research under this theme was on the role of livestock in nutrient cycling in the semi-arid zone of West Africa.

Livestock play a crucial role in sustaining food production in the fragile Sahelian environment. Integrating livestock and crops promotes nutrient cycling, thus helping to maintain soil fertility and crop yields and reducing the need to expand cropping.

Smallholder farmers in sub-Saharan Africa typically use little or no chemical fertiliser. Replacing the nutrients taken up by crops must thus rely on natural processes of nutrient cycling. ILCA's scientists in Niger, working in close collaboration with scientists at the ICRISAT Sahelian Centre, researched systems that managed crop residues and other potential livestock feeds to the benefit of soils, crops and livestock.

Table 32. *Millet components can be used for a variety of purposes. The more nutritious parts can be fed to livestock while less nutritious parts are left in the field to protect and improve the soil.*

		Yield (kg/ha)			Digestibility	Crude protein
Use	Plant part	DM	N	P	(g/kg)	(g/kg)
Food						
	Grain	500	10.54	2.04	747	131
Feed						
	Chaff	420	4.38	0.62	485	65
	Immature panicles	130	2.79	0.43	518	134
	Upper stover	380	4.45	0.72	516	73
	Tillers	190	2.32	0.31	588	804
Soil management						
	Mid stover	430	3.80	0.42	482	57
	Lower stover	670	5.11	0.61	446	508

Studies showed that changes to the way farmers harvest their crops and manage the residues offered a number of possibilities for increasing both crop and livestock production. For example, the upper section of millet stover and the immature panicles and tillers have much higher feeding value than the remainder of the residues (Table 32). Since the grain is harvested by hand, the more nutritious parts could be collected at the same time, leaving the remainder in the field. This selective harvesting could help meet the needs of both livestock feeding and soil management.

Another possibility investigated was grazing millet fields early in the growing season. Even grazing off half the standing crop and weed biomass 10 weeks after the crop had been planted did not have a significant effect on the total above-ground dry-matter yield of the millet at final harvest (2.06 t/ha). Early in the growing season sheep grazed weeds in preference to the millet, reducing competition for water and nutrients later in the growing season.

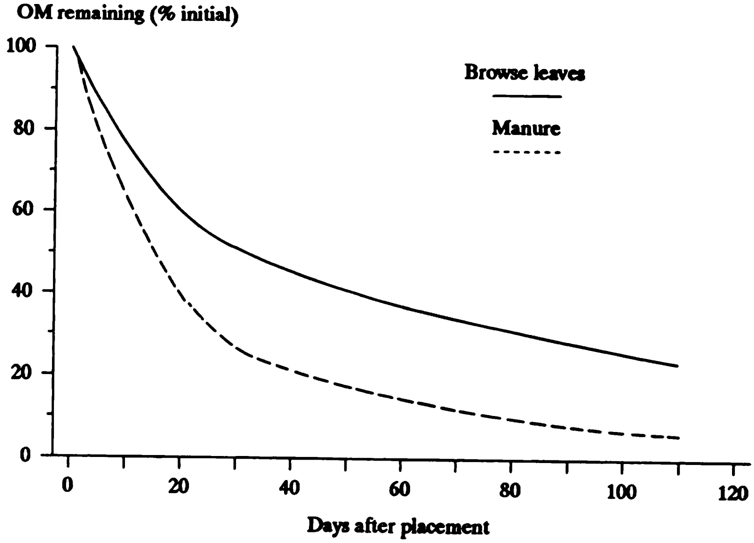
An important aspect of getting best use out of nutrients in the agricultural system is matching nutrient availability with crop demand, not only in terms of quantity but also in time. A flush of nutrients released when crop needs are small will lead to nutrient losses. ILCA trials in Niger demonstrated important differences in nutrient-release patterns between millet stover, browse leaves and sheep manure. All three materials showed decay curves indicating two "pools" of nutrients, one (P_1) consisting of simple compounds that decompose rapidly in the soil, the other (P_2) consisting of compounds that decompose more slowly (Figure 41).

Decay rates in the P_2 pool were markedly affected by the relatively wide range of lignin-to-nitrogen ratios in the materials used in the study. Manure with a high lignin-to-nitrogen ratio had lower daily decay constants but a relatively larger P_2 pool than low-lignin manures.

These differences in pool sizes and rates of decay led to marked differences in nutrient availability patterns. Decomposition of browse leaves tied up significant amounts of nitrogen and phosphorus for nearly two months, after which nitrogen was slowly released. Millet stover tied up nitrogen for 17 days. In contrast, manure released over half its nutrients in the first month after it was applied.

The studies on decomposition of manure just described demonstrated the effect of lignin on the rate of decay of manure. Animal diet can also

Figure 41. *Decay curves of manure and browse, indicating two "pools" of nutrients.*



have a large effect on nitrogen metabolism and excretion and hence on nutrient flows.

ILCA studies in 1992 demonstrated marked diet-related changes in nitrogen outputs of sheep. Sheep fed millet and cowpea residues excreted significantly more nitrogen as a whole, with a greater proportion in the urine, than did sheep fed browse leaves. Feeding browse leaves led to a general shift from soluble nitrogen in the faeces (mainly nitrogen from gut microbes and products of metabolism) to insoluble nitrogen in the faeces (undigested plant proteins). Feeding browse leaves thus led to a general reduction in nitrogen that was excreted in forms that are susceptible to loss through volatilisation or leaching. As a result, the manure from sheep fed browse leaves met 86% of the nitrogen needs of millet, compared with only 60% in the case of manure from animals fed millet and cowpea residues.

The opportunity is thus there to modify the handling of crop residues and the diets of livestock in ways that will not only help increase the productivity of livestock but will also help promote more efficient nutrient flows within the agricultural system as a whole.

One development that may have important implications for nutrient cycling is the trend towards intensive livestock production using zero-grazing. In this system, animals are confined and feed is brought to them. As a result, manure and urine are not returned directly to the soil but accumulate where the animals are housed. This has major implications for both labour use and nutrient flows.

Under traditional systems in Niger, during the dry season cattle, sheep and goats graze crop residues and pasture during the day and are corralled on crop land at night. The animals thus transfer nutrients from pasture areas to crop land and return nutrients in crop residues directly to the soil they came from.

Where animals are housed and feed is brought to them, labour requirements rise dramatically. Feed has to be gathered and brought to the animals, and manure must be transported to crop land to be used as fertiliser. More importantly, from the standpoint of nutrient flows, the material that is transported to the fields will largely be manure, with little of the urine.

ILCA's studies between 1990 and 1992 clearly demonstrated the effect of urine on subsequent crop yields. Millet on plots where manure was applied by hand (i.e. no urine) gave a total above-ground dry-matter yield of 2.9 t/ha, whereas plots on which cattle had been corralled for three nights during the past three dry seasons gave millet yields of 7.3 t DM/ha. The positive effects of urine on millet yields were also evident on plots where cattle had been corralled two or three dry seasons previously (Figure 42).

A similar pattern was observed with sheep manure and urine, with yield increases of up to 73% on plots where sheep were corralled compared with yields on plots receiving manure alone.

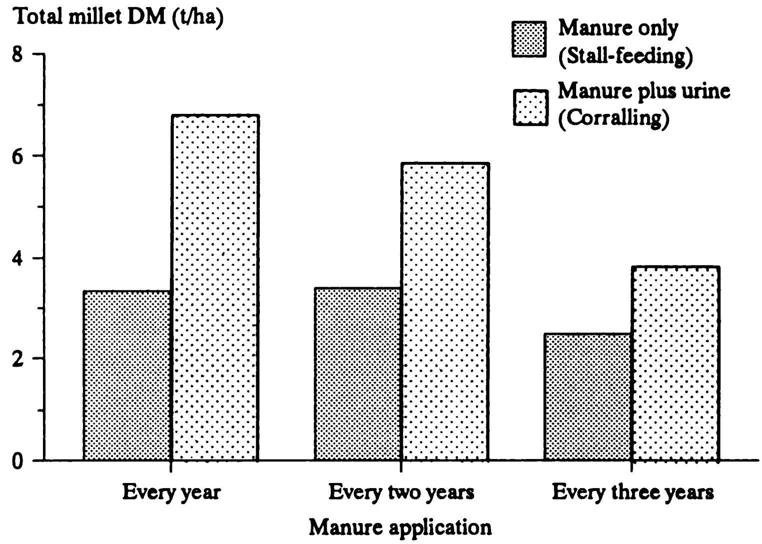


Figure 42. *Effect of corralling animals on crop land on subsequent yields of millet, Niger.*

Given the large effect of corralling animals on the land as compared with spreading the equivalent amount of manure by hand, studies need to determine the relative costs and benefits of intensive production of livestock and the traditional management system.

Resource services

The main focus of this theme was on provision of aerial survey services to research and development organisations in Africa on a cost-recovery basis. Between 1987 and 1991, when the Centre ceased to operate this service, ILCA conducted aerial surveys in Ethiopia, Kenya, Mali, Nigeria and Senegal.

Training and Information

Training

Between 1987 and 1992 ILCA offered a total of 56 group training courses, attended by a total of 949 people. Twenty of the courses were offered in French, the remainder in English.Over the same period nearly 300 scientists benefited from individual training programmes at the Centre. In 1991 ILCA began delivering courses in partnership with national programmes. Joint courses in the Department of Research and Specialist Services in Zimbabwe and with KARI in Kenya increased awareness within ILCA of NARS training needs and was a new way for the Centre to work to strengthen NARS.

This period also saw a new development for the Department, with the establishment of the Training Materials and Methods Unit. This Unit was established to develop training materials and improve the training techniques used by ILCA in its courses. Key among the training materials developed were a series of tape/slide training modules that could be used either in training courses or for individual study. Training manuals were also developed jointly with ICRAF, ILRAD and IITA. The Unit also introduced a teaching component on communication to each ILCA training course.

The development of training materials allowed the value and impact of ILCA's training to extend beyond the participants coming to ILCA, by providing appropriate materials for use in NARS research and training institutes. It was also a necessary support to the increasing emphasis on "training trainers", training NARS scientists in the skills required to design and deliver training in their institutes.

Information Services

ILCA's collection of non-conventional literature on livestock and related topics continued to grow, with microfiching missions to Madagascar and Uganda, and repeat visits to Burkina Faso, Ethiopia, The Gambia, Malawi and Mali.

Between 1987 and 1992 additional specialised bibliographies were compiled, including *Land and tree tenure in humid West Africa: A bibliography, Animal traction: An annotated bibliographic database*, and *Production and processing of milk from cattle in sub-Saharan Africa: A bibliography.*

By the end of 1992, the library's holdings comprised nearly 31 000 books, 7000 reprints, 31 000 microfiches and 1900 periodicals. The in-house global bibliographic database, ILCABIB, contained 71 500

Trainees gaining hands-on experience of testing for mastitis in cattle.

records. ILCA continued to build its information resource but paid increasing attention to using it to provide information services to users.

In 1991, ILCA developed a new information policy that included:

- integrating CAB Abstracts and AGRIS records with local input, which included non-conventional literature collected by ILCA
- restricting the selective dissemination of information (SDI) service to areas central to ILCA's mandate, i.e. animal agriculture and closely allied fields
- building in a feedback mechanism to ensure that the service continued to meet users' needs
- providing an efficient document delivery service
- adopting a new name for the service — ILCAlerts — and
- designing a new ILCAlerts form that helped the user describe his or her research interests in a way that ensured best use from the service.

Since ILCAlerts was restricted to animal agriculture the number of people using the SDI service was reduced from over 500 in June 1991 to just 93 when ILCAlerts came into being. In the service's first five months of operation, ILCAlerts recipients requested copies of a total of 764 articles, clearly demonstrating the need for such an information delivery system in Africa. By the end of 1992, the number of users of ILCAlerts had risen to 357 people in 39 countries.

Publishing

The Publications Section continued to meet all the printing needs of the Centre. In 1990, the Section installed a desk-top publishing (DTP) system, beginning the move away from phototypesetting. Initially, the DTP system was used for only a few publications but by 1992 it was used for almost all typesetting jobs. This enabled greater throughput of jobs and closer involvement of the editors and translators in final production of the publications they worked on.

ILCA's annual report was split into two publications in 1991 to better target audiences. The *Annual Programme Report* gave brief reports on every project in operation during the year and was targeted at scientists interested in the details of the Centre's research, training and information programme. The *Annual Report and Programme Highlights* reported on a few selected topics, usually research areas that had been in operation for some time and were approaching completion or that had produced results with clear indications of potential impact on smallholders. This was written in a more "popular" style, and was targeted at a less technical audience with a broad interest in ILCA's achievements. Printed with full-colour pictures, the "Highlights" was written, designed and produced entirely within ILCA.

Chapter 5

ILCA's second medium-term plan, 1994–98

The period covered by ILCA's first medium-term plan (MTP) was one of great political and economic turbulence both in sub-Saharan Africa and globally, with many changes internationally and in the CGIAR system. Many of these external influences affected ILCA's work over the period of the second MTP. In particular, in formulating its second MTP, ILCA took into account:

- Africa's growing food needs
- progress and priorities in national agricultural research systems (NARS)
- donor priorities
- natural resource management priorities, as set out in UNCED Agenda 21
- the Winrock report on animal agriculture in sub-Saharan Africa
- CGIAR/TAC priorities and strategies and
- recommendations by ILCA's Third External Programme and Management Review.

While these factors influenced the development of the second MTP, the document also represented a further step in the evolution of ILCA's programme and continuing efforts by the Centre to focus its programme in ways that would ensure best use of its resources, expertise and accumulated knowledge of livestock production in sub-Saharan Africa.

Factors influencing ILCA's second medium-term plan

Africa's growing food needs

By 2025, sub-Saharan Africa will have 800 million more people to feed than it had in 1990. Total agricultural output grew by less than 1.5% per year from the 1970s through the early 1990s, and increases in the production of major food crops was far below the 3.1% annual increase in population.

Of the 160 nations on the United Nations development index on the rate of economic and political progress, 32 of the lowest 41 were in Africa. At the end of the 1980s, 41 of the world's lowest-income nations failed to provide enough food for their people to meet minimum nutritional requirements: 29 of these were in Africa. Nineteen countries in sub-Saharan Africa had considerable declines in per capita food supply during the 1980s. Between 1985 and 1991, the number of people in 'abject poverty' in sub-Saharan Africa increased from 120 to 140 million. Sub-Saharan African's share of those living in abject poverty in developing countries also increased, from 19% to 24%.

In the early 1990s, sub-Saharan Africa's imports of basic food staples were growing by about 7% per year and annual food imports were projected to double to 20 million tonnes by the year 2010. Over the period 1975–87, imports of cereals rose from 3.6 to 9.1 million tonnes, while imports of meat tripled from 83 000 to 245 000 tonnes. Milk imports doubled from 1.0 to 2.0 million tonnes. Imports represented 4.5% of the meat and 17% of the milk consumed in sub-Saharan Africa.

Future population growth, rapid urbanisation and income change were all thought likely to contribute to Africa's food demand. To meet projected demand in 2025, Africa would have to import about seven million tonnes of meat and 11 million tonnes of milk annually, at an estimated cost of US$ 16 billion a year.

Progress and priorities in NARS

The rate of technological change in agriculture since the 1960s was slower in Africa than in Asia and Latin America. This was, at least in part, related to the strengths and weaknesses of national organisations, including private firms and non-governmental institutions.

The slower-than-expected uptake of technological innovations was due partly also to policies that transferred wealth from producers of agricultural products to urban consumers. For example, policies that favour imports rather than domestic agricultural production depress the value of land, discourage land-saving innovations and encourage labour migration, all of which make labour-intensive agriculture less profitable. These factors discouraged the adoption of technology for the livestock subsector as well.

However, by the end of 1992 there was increasing evidence of improvements in the agricultural policies of sub-Saharan Africa's nations and some economic progress. Of importance to ILCA was the increase in smallholder milk production in several African countries, particularly in peri-urban areas. This development offered ILCA the possibility of a major impact in an area in which the Centre had a considerable technical, socio-economic and marketing research base.

ILCA was encouraged by the growing quality and output of research reported by collaborative research networks. The Centre engaged in

Research on cow traction in Ethiopia, in collaboration with the Ethiopian Institute of Agricultural Research. The effectiveness of such collaboration convinced ILCA of its continuing validity as an operational mode.

highly productive joint programmes such as the Kenya Agricultural Research Institute (KARI)/ILCA smallholder milk production programme on the Kenya coast and collaboration in Ethiopia with national institutions and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) which produced effective technologies for increasing food production on Vertisols in the densely populated Ethiopian highlands.

The 1991 Biennial Meeting with Leaders of Livestock Research, Development and Training in sub-Saharan Africa reaffirmed the continuing relevance of ILCA's strategy and operational goals. They recommended, however, that ILCA extend its research into the arid tropics and on camels, poultry and pigs. NARS leaders stressed the need to intensify research on animal health and to provide economic assessments of reproductive wastage and trypanotolerance. They also voiced Africa's growing concern about the effects of new technology on the environment. In particular, ILCA was asked to examine the possible adverse effects of introducing more cattle into the humid tropics of West Africa. Socio-economic and marketing studies and the restructuring of networks on the basis of subregions or agro-ecological zones were other topics recommended for ILCA's attention.

Donor priorities

Funding to the CGIAR and to ILCA peaked in 1990 and subsequently decreased. In the five years to 1993, ILCA's donors were influenced by many global events, including world-wide recession. Donors became increasingly concerned about the global environment and natural resources and global alleviation of poverty. The latter concern was prompted by the increasing mobility of economic refugees and the need that this movement emphasised for greater equity between countries and continents, between agro-ecological zones and among households.

By the end of 1992, international research centres, including ILCA, were faced with a need to respond to donors' global concerns in a climate of funding constraints. Centres had to increase programmatic accountability and impact, concentrate on strategic and applied research while increasing the capacity of NARS for adaptive research and technology transfer and to pursue collaborative programmes both among themselves and with advanced institutes in developed countries. These requirements created both difficulties and opportunities for the international research centres.

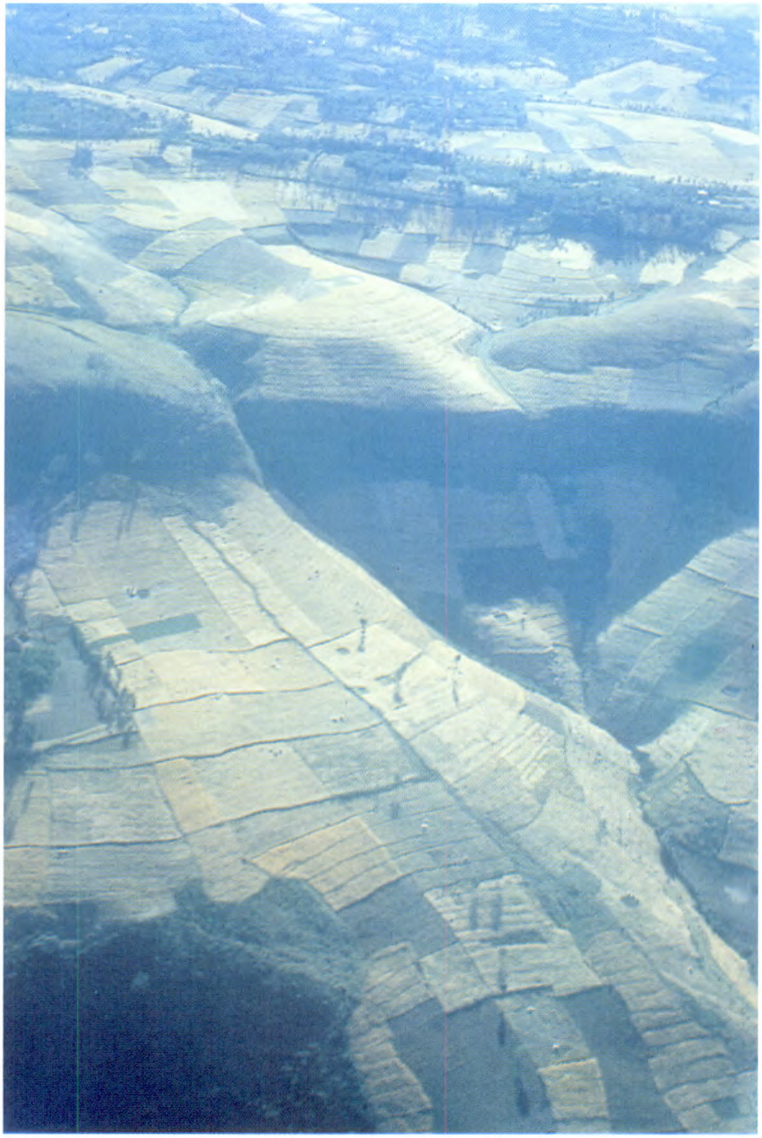
Natural resource management and UNCED Agenda 21

The United Nations Conference on the Environment and Development (UNCED), held in Rio de Janeiro, Brazil, in June 1992, brought the environment to the attention of the world and produced two key documents relating to the work of the international agricultural research centres: the Convention on Biodiversity and Agenda 21. Agenda 21, an 800-page document, outlined specific actions to combat a broad range of environmental problems. Of the 12 objectives of Agenda 21 for sustainable agriculture and rural development, the following were of particular relevance to ILCA:

- conservation and sustainable utilisation of animal genetic resources for sustainable agriculture
- conservation and sustainable utilisation of plant genetic resources for food and sustainable agriculture
- improving farm production and farming systems through diversification of farm and non-farm employment
- land resource planning information and
- land conservation and rehabilitation.

Assessment of Animal Agriculture

During 1991, the Winrock International Institute for Agricultural Development undertook a study entitled *"Assessment of Animal Agriculture in Sub-Saharan Africa."* The study was supported by the Canadian International Development Agency (CIDA), the World Bank, ILCA, the International Laboratory for Research on Animal Diseases (ILRAD), Rockefeller Foundation, the Technical Advisory Committee of the CGIAR (TAC) and the United Nations Development programme.



Cultivation on steep slopes in the Ethiopian highlands. The risks such activities pose for the environment are huge, and must be taken into account in research programmes.

The study stemmed from a common recognition by development agencies, the CGIAR and international agricultural research centres in Africa that such an assessment was needed and that it could best be done by pooling resources in a single, unified effort.

The final report stressed that research resources should be concentrated on:

> *". . . supporting, accelerating, and helping to direct the natural forces of intensification of agriculture and the evolution and maturation of mixed crop–livestock farming systems that will make agriculture more productive and sustainable, while at the*

same time improving the social and economic conditions of people."

The report highlighted the need for increasing the purchasing power of the poor, improving the quality and quantity of animal products and improving the management of natural resources in sub-Saharan Africa. To achieve food self-reliance in the continent and raise incomes, the report noted the need for faster technological progress and more efficient marketing and input-delivery systems, as well as new employment opportunities in rural-based agro-industries. It suggested that these aims could be achieved by increased efforts in research and training, accompanied by policies giving farmers incentives to produce more.

The research priorities recommended for the livestock sector included improving the feed supply (forages for ruminants and coarse grains, root crops and oilseeds for poultry and pigs); animal health (including control of vector-borne diseases, identification of genetic resistance to diseases and parasitism, management strategies and control measures for trypanosomiasis, tick-borne diseases and dermatophilosis, and health delivery systems); genetic improvement (particularly for milk production and of trypanotolerant livestock); natural resource management (including soil fertility, rangeland ecology, monitoring of land-use practices and their effects on the environment and game–livestock production systems); policies relating to development of animal agriculture; and strengthening of national and regional research institutions.

The Winrock report concluded that the most promising pathways for increasing livestock production in sub-Saharan Africa were to expand:

- crop–livestock farming in the semi-arid, subhumid and highland agro-ecological zones
- the use of innovative technology and farm inputs in the cool tropics and
- intensive commercial poultry and pig production systems.

CGIAR/TAC priorities and strategies

In 1992, TAC examined CGIAR priorities and strategies by comparing the value of production of various commodities with the CGIAR's investment in research on these commodities. The congruence analysis was modified by such factors as the number of poor people, total usable land area, efficiency, equity, sustainability, strength of national programmes and self-reliance. The results were used to set priorities by region, agro-ecological zone, production sector and commodity.

TAC recommended a substantial increase in research on resource management, including germplasm conservation. Higher priority was also given to socio-economic, public policy and public-management research. In comparison, institution building and activities aimed at developing and managing production systems were given lower priority (although not in sub-Saharan Africa, where their priority was to be maintained), while germplasm enhancement and breeding priorities were kept at the existing level.

According to TAC, the subhumid tropics, the higher-rainfall areas of the semi-arid tropics and the cool tropics offer the greatest potential for increasing livestock production in sub-Saharan Africa. Productivity and income gains in these zones were expected to come from integrated crop–livestock production systems that had dairying, animal traction, poultry and pig production components. To develop such systems, research should focus on improving feed supplies, animal health and animal genotypes, and on natural resource management and the economics of livestock production. Opportunities for technical interventions in the drier semi-arid and arid tropics were considered too limited (despite the large number of ruminant livestock supported by these areas) to warrant a major research effort.

TAC confirmed ILCA's perception that livestock research in the CGIAR system be restricted to cattle, sheep and goats and to meat, milk and traction. High priority was to be given to increasing livestock productivity in the subhumid and semi-arid tropics and in the highland areas. Elsewhere, livestock research was to be an important component of research on agricultural production systems. TAC recommended close integration of livestock production and animal health research programmes. The emphasis on mixed crop–livestock systems called for a redirection of some work by plant-oriented international research centres.

In its paper entitled *"Priorities and Strategies for Livestock Research"*, TAC recommended that priority be given to the following areas:

- **Animal health.** Strategic research on the epidemiology of, and genetic variances associated with, vector-borne diseases, such as trypanosomiasis, theileriosis, cowdriosis and dermatophilosis, leading to a better understanding of the host–pathogen relationships and development of vaccines and/or other control measures; identification of the genetic basis of resistance to parasites coupled with the development of herd/flock health-control measures and preventive animal-health technology appropriate to smallholder farmers.
- **Animal nutrition.** Physiological and biochemical manipulation of animal growth and feed digestion processes to better exploit high-fibre feeds.
- **Animal genetics.** Characterisation of indigenous animal genetic resources with emphasis on adaptability and disease tolerance and use of molecular genetics to enhance indigenous germplasm.
- **Feed resources.** Development of more-digestible, nitrogen-efficient forages and by-product feeds to support ruminant production within integrated crop–livestock systems; exploitation of high-biomass and

protein-rich feeds to support the expansion of pig and poultry production; development of forage and pasture production.

- **Livestock production systems**. Constraint analysis; development and evaluation of livestock production systems, with emphasis on integrated crop–livestock farming and evaluation being based on socio-economic criteria, bio-energetic efficiency and resource sustainability.
- **Natural resource management**. The study of soil–plant–animal interactions in reference to integrated crop–livestock systems, land use and sustainable resource management.
- **Policy analysis**. Identification of key policy options needed to support livestock development, to protect fragile marginal lands used for livestock production and to enhance the development and integration of crop and livestock production.

EPMR priorities

The Third External Programme and Management Review (EPMR) of ILCA, completed in January 1992, endorsed the Centre's strategic choices of species, target groups and commodities (see Table 33) but suggested that the Centre consider increasing its work on sustainable resource management in the semi-arid agro-ecological zone. The panel also felt that the Centre was over-represented in the subhumid agro-ecological zone of West Africa but under-represented in the semi-arid and subhumid regions of southern Africa.

The review panel recommended that ILCA continue conducting research with a farming systems perspective, agreeing that this should not preclude strategic research when needed. They cautioned against a major move towards more "upstream" research in the near future, because they felt that this was inconsistent with the needs of ILCA's primary target group, smallholders. The EPMR highlighted ILCA's comparative advantage for interdisciplinary research over most NARS in Africa and emphasised the need for the Centre to work with NARS and to continue improving their research capacity.

The resources available to ILCA at the end of the third quinquennium (US$ 19.4 million in 1992) were considered insufficient to address adequately the essential research priorities indicated in the Centre's first medium-term plan (US$ 28.1 million for 1992). The EPMR panel recommended that the Centre increase the number of social scientists and economists at its zonal sites. The balance of animal and plant scientists between sites and headquarters was deemed satisfactory.

Looking further ahead, the panel stated that:

"The future of ILCA as a CGIAR centre would appear to lie in two main roles. Firstly, it would continue as a multilaterally funded centre carrying out its original purpose of research and

capacity building for national systems. Secondly, it could also operate as a knowledgeable and responsible agency through which bilateral or project donors could direct funds in an effective way. This would include funding of specific projects within ILCA's operation mandate and 'in-trust' funding for purposes such as research support networks." [The Third External Programme and Management Review of ILCA, 1992, page 140.]

This implied that ILCA should continue focusing on:

- collaborative applied research on crop–livestock farming systems and basic and strategic research as necessary
- developing collaborative research networks and building capacity for livestock research in NARS.

Summary of proposed priorities

The priorities identified by the various groups and reports showed a marked similarity to ILCA's priorities (Table 33).

Table 33. *Strategic priorities for livestock research.*

Variable	Winrock study	TAC livestock strategy	ILCA strategy
Species	Cattle, sheep, goats (swine, poultry)	Cattle, sheep, goats (swine, poultry)	Cattle, sheep, goats (swine, poultry)
Products	Milk, meat, traction	Milk, meat, traction	Milk, meat, traction, manure
AEZ (in SSA)	Semi-arid, subhumid, cool tropics	Subhumid, cool tropics	Semi-arid, subhumid, humid, cool tropics
Target group	Smallholder farmers	Smallholder farmers	Smallholder farmers
Production system	Crop–livestock	Crop–livestock	Crop–livestock

Items in parentheses were considered of secondary priority.

Developing the programme

"Resources currently available are well below those required to meet the needs of the 1989–93 medium-term plan... Under these circumstances, the only way ILCA can carry out high-quality research ... is to make its focus even sharper by reducing the

scope of its work . . . ILCA should reduce the number of research themes it addresses . . .

"As ILCA plans for the next five years and beyond, its strategic planning process must take into account not only the research needs and priorities . . . [of livestock research] . . . but also its special role as a CGIAR (Consultative Group on International Agricultural Research) centre and the necessity to forge and manage new research partnerships and alliances . . ." [Report of the Third External Programme and Management Review of ILCA]

By 1993 there was a widely recognised need for ILCA to tighten its programme focus in order to maintain a critical scientific mass with substantially less funds than anticipated in the Centre's first medium-term plan (US$ 14.3 million actual expenditure vs US$ 29.8 million projected for 1993). Also, following the revision of the CGIAR strategies and priorities, ILCA needed to reassess the contribution and relevance of its programmes to the wider needs of the livestock owners served by the CGIAR centres both in sub-Saharan Africa and globally.

These additional programme requirements — greater focus within ILCA and increased involvement of the Centre in inter-institutional partnerships within the CGIAR — were addressed specifically by the Centre's medium-term plan for 1994–98. The MTP proposed a specific and narrower focus within the Centre's long-term goal of sustainable increases in livestock output, and put forward proposals on how ILCA would participate in an integrated approach to livestock research within the CGIAR.

The specific medium-term goal adopted by the MTP was:

"Improved and sustainable milk and meat production from small-holder crop–livestock systems."

Underlying this goal statement were a number of changes in emphasis in the Centre's programme and approach:

- **Sustainability.** There was an increased emphasis on sustainable production systems, with particular attention to income generation, equity issues, risk aversion, natural resource management, appropriate technologies and policies that would promote sustainable development of the livestock sector. While this philosophy had underlain ILCA's programme since the Centre was established, the MTP raised its profile in light of donor concerns for the environment.

- **Biodiversity.** The MTP highlighted conservation and characterisation of plant and animal genotypes.

- **Milk and meat production.** While these commodities had been a major focus of ILCA's first MTP, their primacy as livestock products was reiterated in the second MTP, with other livestock products such as animal traction, hides and skins and manure being defined as 'associated products.'

Collecting seed of Gliricidia sepium. *Collecting, characterising and utilising plant and animal genetic resources was to be a key area of ILCA's programme under the second MTP.*

- **Ecozones.** ILCA removed a zonal or regional reference from the medium-term goal statement to emphasise the inter-zonal and global nature of livestock production.
- **Markets and marketing.** The second MTP emphasised ILCA's focus on markets and marketing of meat and milk as factors that 'pull' livestock industries towards sustainable development. The MTP noted that markets for livestock products are commonly far from where the products are produced, citing the examples of Lagos, Douala, Accra and Abidjan in the humid zone, where there are few livestock, and Nouakchott and Niamey in drier zones where there are limited opportunities for forage production. Thus, there was a need to consider both markets and production sites in setting the zonal priorities for ILCA's work.

ILCA's seven programme themes

The second ILCA medium-term plan was delineated within seven programme themes:

- **Productivity and sustainability of mixed crop–livestock systems.** Under this theme, ILCA intended to address aspects of the interactions between livestock and related cropping systems such as nutrient cycling, animal traction for cultivation and improving the production feed from crops and forage legumes (including multipurpose trees). Collaborative research was envisaged with the International Institute of Tropical Agriculture (IITA) on sustainable crop–livestock production systems in the subhumid zone, alley farming and other projects carried out through the feed resources network; with ICRISAT in the Vertisol management programme in the highlands of Ethiopia and on nutrient cycling in Sahelian agropastoral systems; and the International Centre for Research in Agroforestry (ICRAF) in studies on the utilisation by livestock of multipurpose trees in the cool highland tropics.

- **Market-oriented smallholder dairying.** This theme was intended to address feed packages for dairy production; genetic improvement of dairy cattle in tropical conditions; managing livestock reproductive performance and health status; and processing and preservation of dairy products. Collaboration was envisaged with KARI, the National Animal Production Research Institute (NAPRI), Nigeria, and through the Cattle Research Network (CARNET).

- **Conservation of biodiversity.** This theme was to include research on animal and forage genetic resources. Collaborative projects were envisaged with the International Plant Genetic Resources Institute (IPGRI) on conservation of plant genetic resources; with the Centro Internacional de Agricultura Tropical (CIAT) in forage germplasm evaluation and in the storage and exchange of forage legume genetic resources; with IITA in research on multipurpose trees and herbaceous forage germplasm; with ICRAF in evaluating multipurpose trees; with ILRAD in research on the genetics of disease and parasite resistance; and with the Food and Agriculture Organization of the United Nations (FAO) and African NARS in the characterisation of indigenous African animal genetic resources through CARNET and the Small Ruminants Research Network (SRNET).

- **Biological efficiency of livestock.** The focus of this theme was to be research aimed at improving the health, nutrition, reproductive efficiency and genetic potential of livestock. Collaboration was envisaged with ILRAD in research on animal health, with the crop centres in feed utilisation by livestock and with advanced institutes in developed countries on rumen microbiology, embryo technology, genetics of parasite resistance and other strategic research on biological efficiency.

- **Livestock production under trypanosomiasis risk.** The research proposed under this theme related to the genetics of trypanotolerance, the control and epidemiology of trypanosomiasis and to the assessment of the economic and environmental impact of trypanosomiasis-control programmes. This work was to be carried out in collaboration with ILRAD, the International Trypanotolerance Centre (ITC), the Centre international de recherche-développement sur l'élevage en zone subhumide (CIRDES), NARS and advanced institutes.

- **Livestock and resource management policy.** This theme was aimed at addressing policy and institutional issues relating to natural resource management, the sustainability of mixed crop–livestock systems, land use and tenure, regional trade, demand and markets, livestock health and disease control. In addition, it was intended to address issues related to assessing the impact of livestock research. A joint programme was planned with the International Food Policy Research Institute (IFPRI) on livestock and resource management policy.

- **Strengthening national research capacities.** This theme was to focus on strengthening the research capacities of NARS for livestock research through collaborative research networks — the African Feed Resources Network (AFRNET), SRNET and CARNET; provision of germplasm and technical services to collaborating NARS; provision of training and information; and organisation and management counselling on livestock research and development.

An integrated programme

These medium-term programme themes were closely integrated. The first two (largely 'commodity'-oriented themes were to use the technologies and policy options generated under the four themes on *Conservation of biodiversity, Biological efficiency of livestock, Livestock production under trypanosomiasis risk* and *Livestock and resource management policy*. In turn, the constraints identified by the commodity themes were to help set the priorities for research in the biological and socio-economic themes. The seventh theme, *Strengthening national research capacities*, was seen as particularly important for the development of equal research partnerships between ILCA and NARS to help ensure that the potential for impact from research would be realised.

The MTP foresaw a number of changes in the content of projects, with 1993 being a transitional year between the first and second MTPs. Several major research activities that were part of the 1988–93 MTP ended in 1993, releasing resources to support new initiatives. The second MTP envisaged the following changes:

- In the highlands zonal programme in Ethiopia, research emphasis was to shift from Vertisols management to cow traction and feed development.

- In the subhumid/humid zonal programme at Ibadan, Nigeria, emphasis was to shift from alley farming and small ruminants to market-oriented smallholder dairying.

- The responsibilities of the former Plant Sciences Division at ILCA headquarters were to be broadened to include soil, water and nutrient management and cycling, geographical information systems, and environmental impact assessment. The Division was renamed 'Environmental Sciences' to reflect these refocused agro-ecological research responsibilities.

- Scientists in the Socio-economic Sciences Division at ILCA headquarters were to lead new research on economic impact assessment and on livestock and resource management policy (the latter through a joint programme with IFPRI). The MTP envisaged considerable expansion of the activities of the Division, including recruitment of several sociologists.

- ILCA's work on animal traction was to be realigned to emphasise strategic work addressing physiological trade-offs among work, lactation, growth and reproduction in multipurpose animals. Research on implements, feeding and management systems for draft animals and the introduction of animal traction to new areas were to be addressed primarily by NARS scientists through the Cattle Research Network.

MTP reviewed and approved

ILCA's second MTP was submitted to TAC for review and comment in March 1993. Although it was well received and generally approved, events in the CGIAR system were to overtake its implementation. These are dealt with in the following chapter.

Chapter 6

Moves towards a global livestock research institute

When ILCA and ILRAD were established in the early 1970s, the CGIAR considered it likely that the two centres would eventually come together in a unified livestock research entity. This possibility again emerged with the external reviews of the two centres in 1991/92, when the review teams were asked to consider whether the plan to amalgamate the two centres should be revived. In the event, both teams recommended increased cooperation between the centres, but were not in favour of a merger. Winrock's report, *"Assessment of Animal Agriculture in Sub-Saharan Africa"*, also recommended closer collaboration rather than merger.

At the same time that ILCA and the International Laboratory for Research on Animal Diseases (ILRAD) were developing their medium-term plans for 1994–98, the Technical Advisory Committee (TAC) of the CGIAR was developing and refining its proposals for priorities and strategies for livestock research in the CGIAR.

A discussion draft of TAC's proposals was presented and discussed at International Centers Week in Washington, DC, in October 1992. ILCA's Board of Trustees questioned the basis and conclusions of this TAC proposal. In particular, the Board challenged the figures used for CGIAR spending on livestock research and for the value of production from livestock. ILCA's figures suggested that the CGIAR was under-investing in livestock research, even in sub-Saharan Africa.

TAC released a revised version of its priorities and strategies paper in April 1993, in time for the CGIAR's mid-term meeting in Puerto Rico in May 1993.

The key elements of the TAC priorities and strategy paper are presented in Chapter 5 (*ILCA's second medium-term plan, 1994–98*), as are the other considerations that when into shaping ILCA's second medium-term plan. But in the event, TAC's proposals were superseded by decisions taken at the mid-term meeting.

The key issue raised by TAC was that of how the CGIAR's livestock research could best address the needs outside sub-Saharan Africa. TAC's analyses had documented the important role of livestock in mixed crop–livestock systems in all the major regions of the developing world, and their considerable economic contribution in these regions. Further analyses indicated that the vast majority of the CGIAR's expenditure on livestock research was in sub-Saharan Africa, with lesser amounts in the Latin America and Caribbean (LAC) and West Asia and North Africa (WANA) regions, and virtually none in Asia, despite the importance of livestock in that region.

ILCA had championed the cause of mixed crop–livestock systems for many years, and TAC's priorities and strategies were in line with this priority, highlighting the use of ecoregional programmes as a means of bringing together crop and livestock research in "systems research" programmes in different agro-ecological zones. TAC's proposals would have retained ILCA and ILRAD as separate entities, but with ILCA as an ecoregional centre focusing on applied research in a single ecoregion and ILRAD as a global centre working on strategic research in animal nutrition, physiology and genetics as well as diseases.

Livestock Steering Committee

The CGIAR mid-term meeting in May 1993 went beyond these proposals with a decision to develop a unified strategy for livestock research in the CGIAR system. It established a "Steering Committee on Livestock Research in the CGIAR" to "identify priority activities for international livestock research, which would be managed through a single institution and be constrained by the current proportion of CGIAR resources allocated to livestock."

The members of the Steering Committee (SC) were Dr Lucia Pearson de Vaccaro (Chair), Venezuela; Professor H.C. Dieter F.R. Bommer (ILCA Board Chairman), Germany; Dr John C. Davies, UK; Dr John McIntire, World Bank; Dr Cyrus G. Ndiritu, Kenya; Professor N.O. Nielsen (ILRAD Board Chairman), Canada; and Dr John Vercoe, Australia. The Committee was supported by Dr Michael Collinson of the CGIAR Secretariat.

The SC presented its proposals for discussion at International Centers Week 1993. The central element of its proposal was the establishment of a single livestock research institute, tentatively called the Centre for International Livestock Research, which would bring together components of the programmes of ILCA and ILRAD. Other important elements of the SC's report included:

- **TAC Livestock Strategy.** The report concurred with the TAC Livestock Strategy regarding species, commodities, ecoregions (semi-arid, subhumid and cool tropics), the seven priority research areas (health, nutrition and physiology, genetics, feed resources, production systems, natural resource management, and policy analysis), and expansion of CGIAR livestock research to Asia and Latin America.
- **Unified strategy.** Key observations made by the SC, and key elements of the unified strategy proposed, included the following:

- Livestock are an important and integral part of overall production systems, as well as an end in themselves.
- Research should emphasise mixed (crop–tree–livestock) production systems.
- Research should be demand driven, arising from farm-level problems.
- The complexity of livestock-related systems requires integrated, multidisciplinary research.
- Livestock-related production systems in the developing world are very diverse and research needs would have to be prioritised.
- The unified strategy would underpin a strategic research agenda to solve priority problems that are global or transregional in nature.
- The strategic research agenda and the linkages into ecoregional programmes would be equally important parts of the core programme within the unified strategy.

- **Mandate.** Key elements of the proposed mandate included:
  - a world centre for strategic research
  - support to national and regional efforts

A crossbred dairy cow pulling a seed drill in China. The new institute will address the many livestock research needs outside Africa, bringing new strength to the CGIAR system.

- convening of collaborative efforts in livestock-related research and institution-building across the CGIAR system.

- **Institutional basis.** The SC noted the need for a holistic approach to research to ensure the correct identification of problems and development of optimal solutions. The proposal was to integrate programmes from ILCA and ILRAD and emphasise collaboration with other IARCs at the ecoregional level.

- **Strategic planning.** The SC identified the development of a strategic plan, acceptable to the various stakeholders (Boards of the two centres, host countries, donors, NARS partners inter alia), as the key to the process. The SC proposed that an Implementing Group be responsible for managing the process. The SC also proposed two "task forces", one to develop the strategic plan and another to develop the medium-term plan for the new centre.

- **Institution building.** The SC emphasised the importance of the new institute as a role model for other institutions, noting that animal health and production divisions are commonly separated in national research institutes in the developing world. Information and training were identified as vital elements of the new institute's activities.

- **Global research.** The SC stressed that the emphasis of the programme should be on strategic research addressing major livestock production problems with transregional significance.

- **Inter-regional collaboration.** The SC noted that livestock-related activities in the CGIAR centres involve common issues and interests which could best be addressed through coordinated efforts, and proposed that the new institute should act as a "convener" of such collaborative efforts.

- **Ecoregional research.** The SC identified priority programmes with livestock components in the seven priority ecoregions identified by TAC; three in sub-Saharan Africa, two in Asia and one each in West Asia/North Africa and Latin America. The SC noted that ecoregional research would provide the major opportunity for collaborative research between the new centre and CGIAR crop centres and regional centres.

- **Timetable.** The SC proposed an ambitious schedule for the establishment of the new centre, with the new centre coming into being in January 1995.

The report of the SC received the endorsement of the ILCA and ILRAD Boards of Trustees in October 1993, prior to it being presented at International Centers Week in Washington, DC, later that month. The ILCA Board of Trustees argued for an even faster progress towards establishing the new institute. The CGIAR approved the SC's report, and steps were taken to put it into effect.

Moves towards a new institute

In December 1993, the CGIAR designated the Rockefeller Foundation as the "Implementing Agency" to manage the establishment of the new centre. The Foundation had been instrumental in establishing both ILCA and ILRAD in the 1970s. Rockefeller Foundation appointed Robert Havener to coordinate the process on its behalf. Mr Havener was immediate past President of Winrock International and was formerly Director General of the International Maize and Wheat Improvement Centre, CIMMYT.

The Rockefeller Foundation established an Implementing Advisory Group (IAG), chaired by Dr Neville Clarke (former member of the ILCA Board of Trustees and former USAID scientific liaison officer to ILRAD) and comprising representative stakeholders from across the system. The IAG advised the Foundation on the development of the strategy and medium-term plan, and on recommendations for leadership of the new centre. Members of the earlier SC and the chairs of the ILCA and ILRAD Boards of Trustees and their Programme Committees were also members of the IAG, providing continuity between earlier studies and progress towards the establishment of the new centre. Other members represented donor and developing countries and provided a range of geographical perspectives and technical expertise.

Implementing Advisory Group

Professor Anthony A. Adegbola, Nigeria

Professor H.C. Dieter F.R. Bommer, Chair, ILCA Board of Trustees, Germany

Dr Charan Chantalakhana, Thailand

Dr Neville Clarke, USA (Chairman, IAG)

Professor Patrick Cunningham, Ireland

Dr John C. Davies, UK

Dr Hank Fitzhugh, Director General, ILCA

Dr A.R. Gray, Director General, ILRAD

Mr Robert D. Havener, USA

Dr Robert W. Herdt, The Rockefeller Foundation

Professor N.O. Nielsen, Chair, ILRAD Board of Trustees, Canada

Dr Vagn Ostergaard, Denmark

Dr Michel Petit, World Bank

Dr A. Wahab Qureshi, FAO

Dr George Rothschild, Australia

Dr Georges Tacher, France

Dr Lucia Pearson de Vaccaro, Venezuela

A strategic plan takes shape

The IA set up a Strategic Planning Task Force to develop the global livestock research strategy for the CGIAR, the interim strategy for the new institute and its medium-term plan (MTP). The task force was chaired by Professor Patrick Cunningham, an animal geneticist and former director of livestock programmes in the Food and Agriculture Organization of the United Nations (FAO), and included Dr Georges Tacher, former Director of CIRAD–EMVT and a member of the Boards of Trustees of both ILCA and ILRAD. The Task Force involved specialists who were called on to prepare position papers on Asian requirements (Dr C. Devendra, Malaysia), pastoral systems (Dr Ahmed Sidahmed, Sudan), nutrition and feed resources (Dr Ron Leng, Australia), and systems and Latin American requirements (Dr Carlos Sere, Uruguay).

The strategy built on three main reference points enunciated by TAC in its priorities and strategies paper:

1. The activities must be research or research-related. The first objective is the generation of new knowledge or products, while the second includes dissemination, training and cooperative activities.
2. The activities must be international in character, and target CGIAR priorities.
3. The activities must be ones in which the CGIAR centres have a comparative advantage.

Other considerations outlined by the task force were:

- CGIAR centres should be leaders, not followers, in their particular fields of scientific expertise.
- For practical as well as philosophical reasons, the CGIAR centres must seek active partnership with other institutions, particularly in developing countries.
- The responsibility of CGIAR centres extends beyond the production of research information, and includes dissemination of the results to intermediate or end-users as appropriate. This process should be carried out interlinked with training and institution-building activities.
- The programme must particularly acknowledge world concerns about the environment, sustainability, food security and poverty reduction.

The task force also identified the major trends affecting the livestock sector world-wide:

- Most of the increase in production will come from intensification of livestock production in mixed farming systems.

- Urbanisation of consumers will tend to encourage specialisation of producers and, for some products (e.g. poultry and pigs), a shift to industrial-scale production.
- However, almost all production of milk, beef and small ruminant meat, and most pig-meat production, will still come from smallholder systems.
- Pastoral areas will have limited scope for increasing production, but will present challenges in natural resource management.
- New scientific developments will provide significant opportunities for improving productivity, particularly through animal-health interventions.

Of the seven priority research areas identified by TAC, the task force saw three — animal health, animal genetics and nutrition — as being mainly in the realm of strategic research with global relevance, regarding the remaining four — feed resources, production systems, natural resource management and policy analysis — as being primarily strategic and applied research with ecoregional relevance. The task force believed that the International Livestock Research Institute (ILRI) had a comparative advantage in strategic research on animal health and animal genetics, and would play a leading role in these areas, while the centre would play a major contributory role to ecoregional programmes involving a livestock component.

The interim strategy developed by the task force was reviewed by the IAG and TAC in March 1994. Both groups made substantial recommendations that were subsequently incorporated into a subsequent draft of the strategy, which was discussed at a joint meeting of the Executive Committees of the Boards of Trustees of both ILCA and ILRAD at ILCA on 6 May 1994 and was subsequently presented at the CGIAR mid-term meeting in New Delhi, India, in May 1994.

Developing an interim medium-term plan

The job of preparing an interim medium-term plan for the new centre, by this time being referred to as the International Livestock Research Institute (ILRI), initially fell to ILCA and ILRAD staff.

A first draft of the MPT was developed by bringing together key areas of research from the MTPs of the two centres under the priority research areas identified by TAC. This document, *"Discussion Draft — Interim Medium-term Plan for the International Livestock Research Institute"*, was discussed along with the draft strategy by the IAG and TAC at their March 1993 meetings. It was subsequently discussed at the joint meeting of the ILCA and ILRAD Board Executive Committees, and Professor Cunningham and Dr Tacher worked with ILCA and ILRAD staff to revise the document, taking into consideration comments and recommendations from all parties. The resultant *"Indicative Medium-term Plan for the International Livestock Research Institute"* was reviewed by both ILCA and ILRAD staff before being submitted to TAC for review and approval.

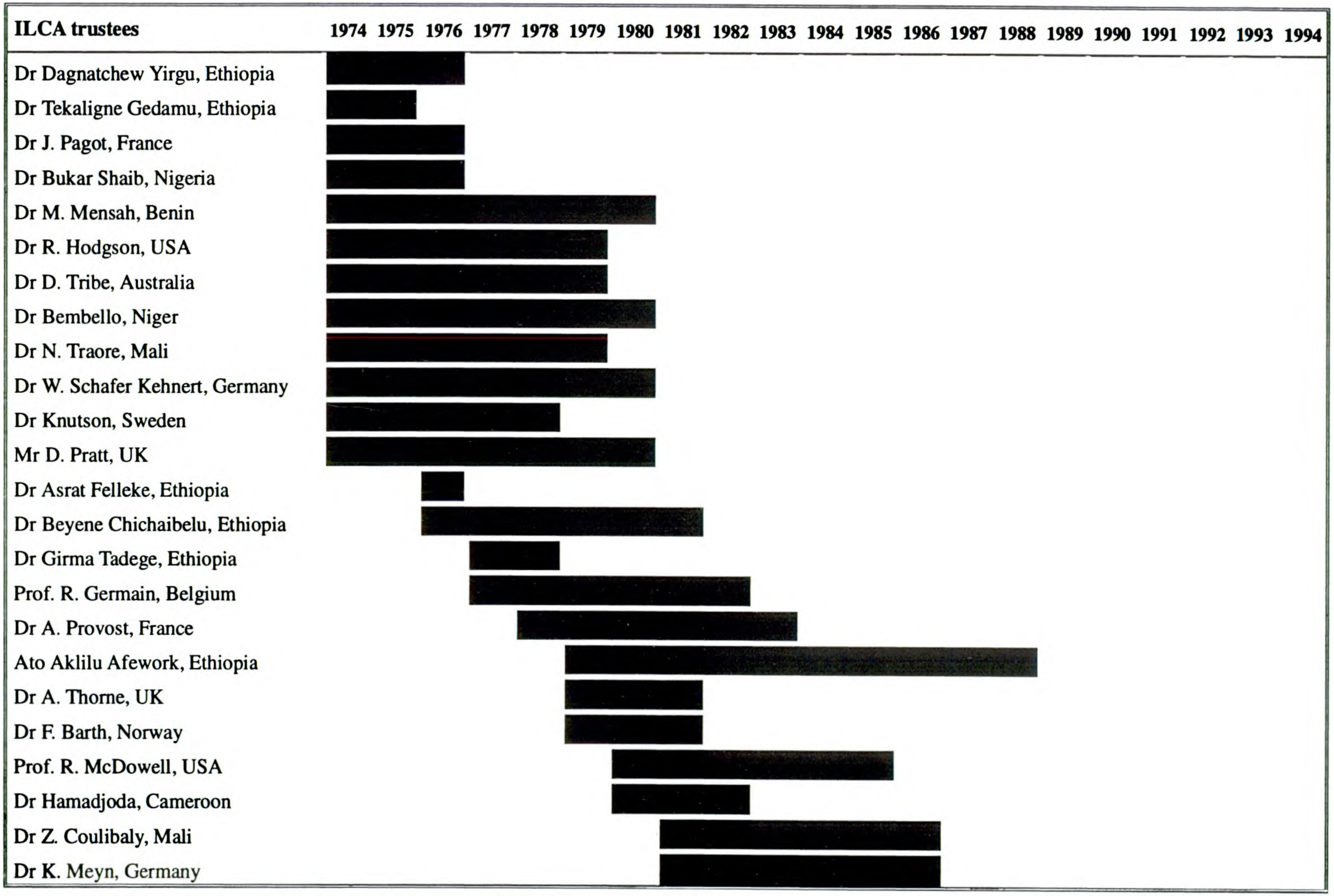
Benefits for livestock producers world-wide

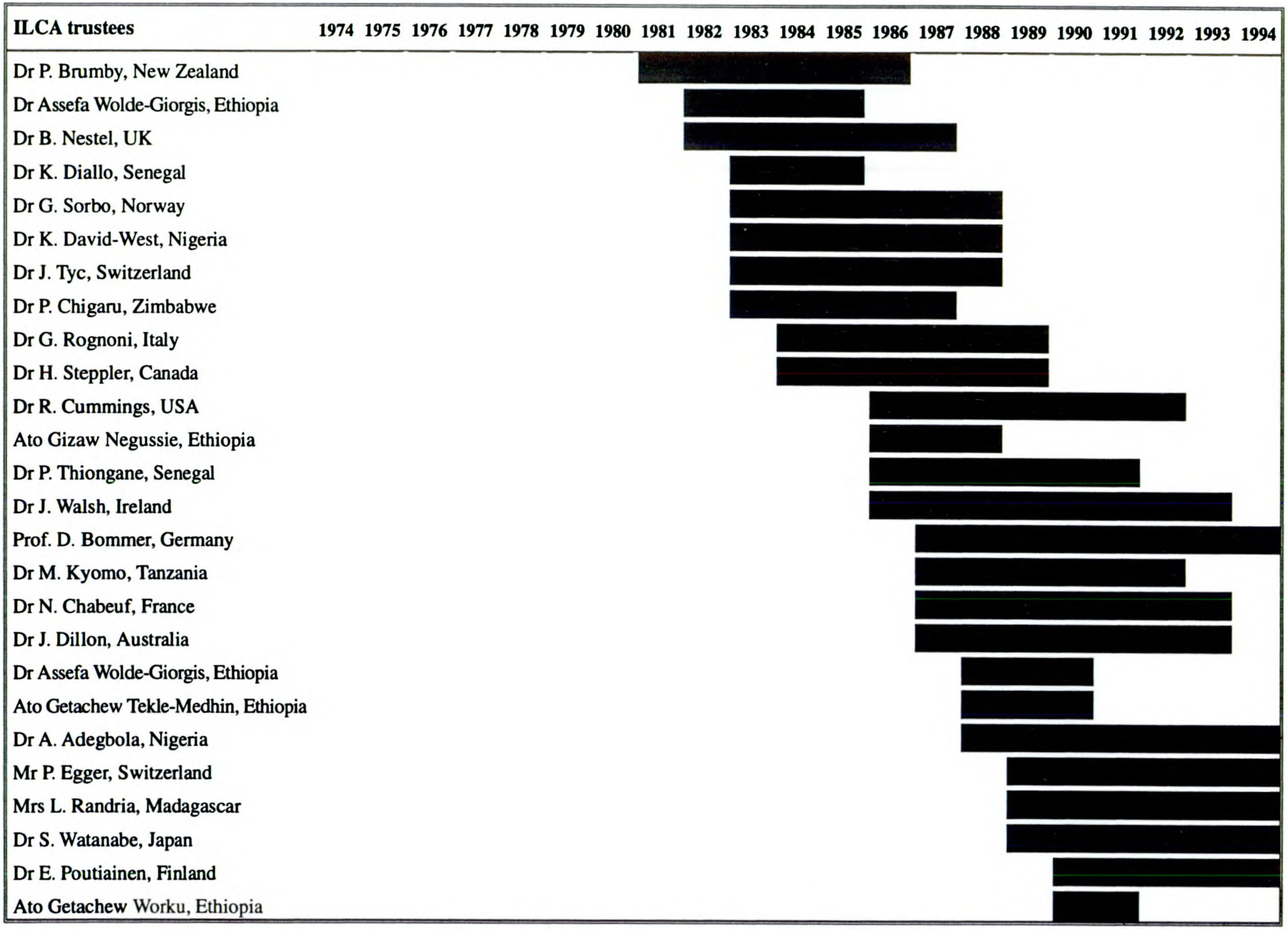
Livestock are part of smallholder agricultural systems world-wide. Until 1994, the commitment of the CGIAR to livestock research was limited to the two specialised institutes in sub-Saharan Africa, with lesser amounts of work in Latin America and West Asia/North Africa. The recognition of the importance of livestock world-wide opened the way for the development of a global strategy for livestock research in the CGIAR.

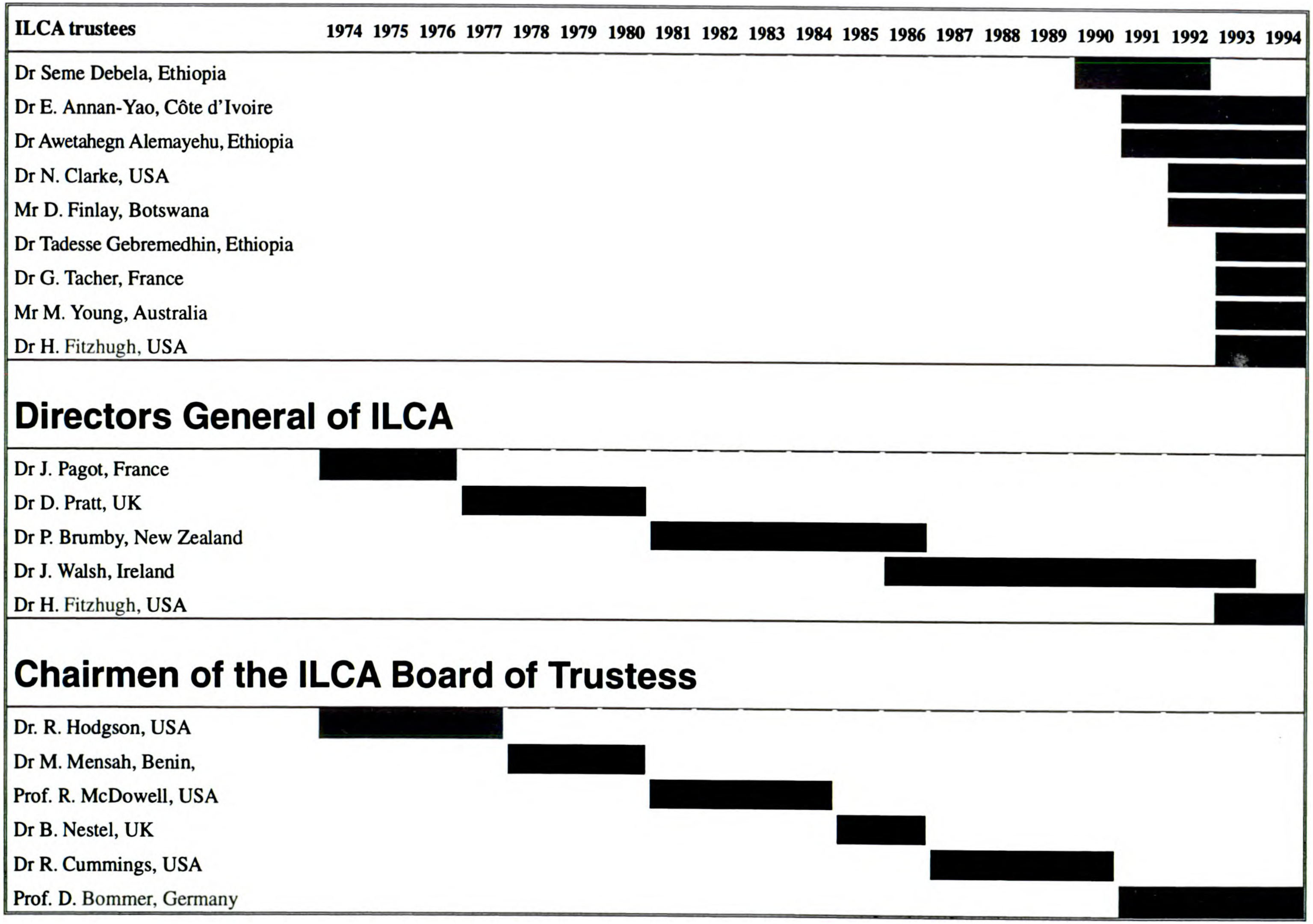
From being largely isolated in its conviction that livestock are the key to more productive, sustainable farming systems, ILCA has seen its vision widely accepted in the CGIAR system. The challenges facing the new institute are enormous, but the potential benefits for smallholder farmers are equally large.

Annexes

ILCA Trustees, 1974–1994




ILCA trustees
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
Dr P. Brumby, New Zealand
Dr Assefa Wolde-Giorgis, Ethiopia
Dr B. Nestel, UK
Dr K. Diallo, Senegal
Dr G. Sorbo, Norway
Dr K. David-West, Nigeria
Dr J. Tyc, Switzerland
Dr P. Chigaru, Zimbabwe
Dr G. Rognoni, Italy
Dr H. Steppler, Canada
Dr R. Cummings, USA
Ato Gizaw Negussie, Ethiopia
Dr P. Thiongane, Senegal
Dr J. Walsh, Ireland
Prof. D. Bommer, Germany
Dr M. Kyomo, Tanzania
Dr N. Chabeuf, France
Dr J. Dillon, Australia
Dr Assefa Wolde-Giorgis, Ethiopia
Ato Getachew Tekle-Medhin, Ethiopia
Dr A. Adegbola, Nigeria
Mr P. Egger, Switzerland
Mrs L. Randria, Madagascar
Dr S. Watanabe, Japan
Dr E. Poutiainen, Finland
Ato Getachew Worku, Ethiopia


ILCA trustees
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
Dr Seme Debela, Ethiopia
Dr E. Annan-Yao, Côte d'Ivoire
Dr Awetahegn Alemayehu, Ethiopia
Dr N. Clarke, USA
Mr D. Finlay, Botswana
Dr Tadesse Gebremedhin, Ethiopia
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Dr J. Pagot, France
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Dr J. Walsh, Ireland
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Chairmen of the ILCA Board of Trustess
Dr. R. Hodgson, USA
Dr M. Mensah, Benin,
Prof. R. McDowell, USA
Dr B. Nestel, UK
Dr R. Cummings, USA
Prof. D. Bommer, Germany

Training participants by training category and year

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Total
Training courses	16	28			17	13	74	24	111	144	160	178	216	176	112	107	71	1447
Technician Associates						2	10	15	19	17	20	23	13	15	15	21	7	177
Research Fellows					2		1			3	2	4	6	4	6	8	4	40
Undergraduate Associates	1		1		4	1	3	3		9	5	5	3	6	4	8	1	54
Research Associates									2		1	2				2	2	9
Graduate Associates		4		5	1	5	1	2	8	10	7	18	22	16	6	12	12	129
Postdoctoral Associates						1	5	4	5	4	4	2	6	3	5	8	2	49
Visiting Scientists					1	1	1		1	3		2	4	4	1	3		21
Total	17	32	1	5	25	23	95	48	146	190	199	234	270	224	149	169	99	1926

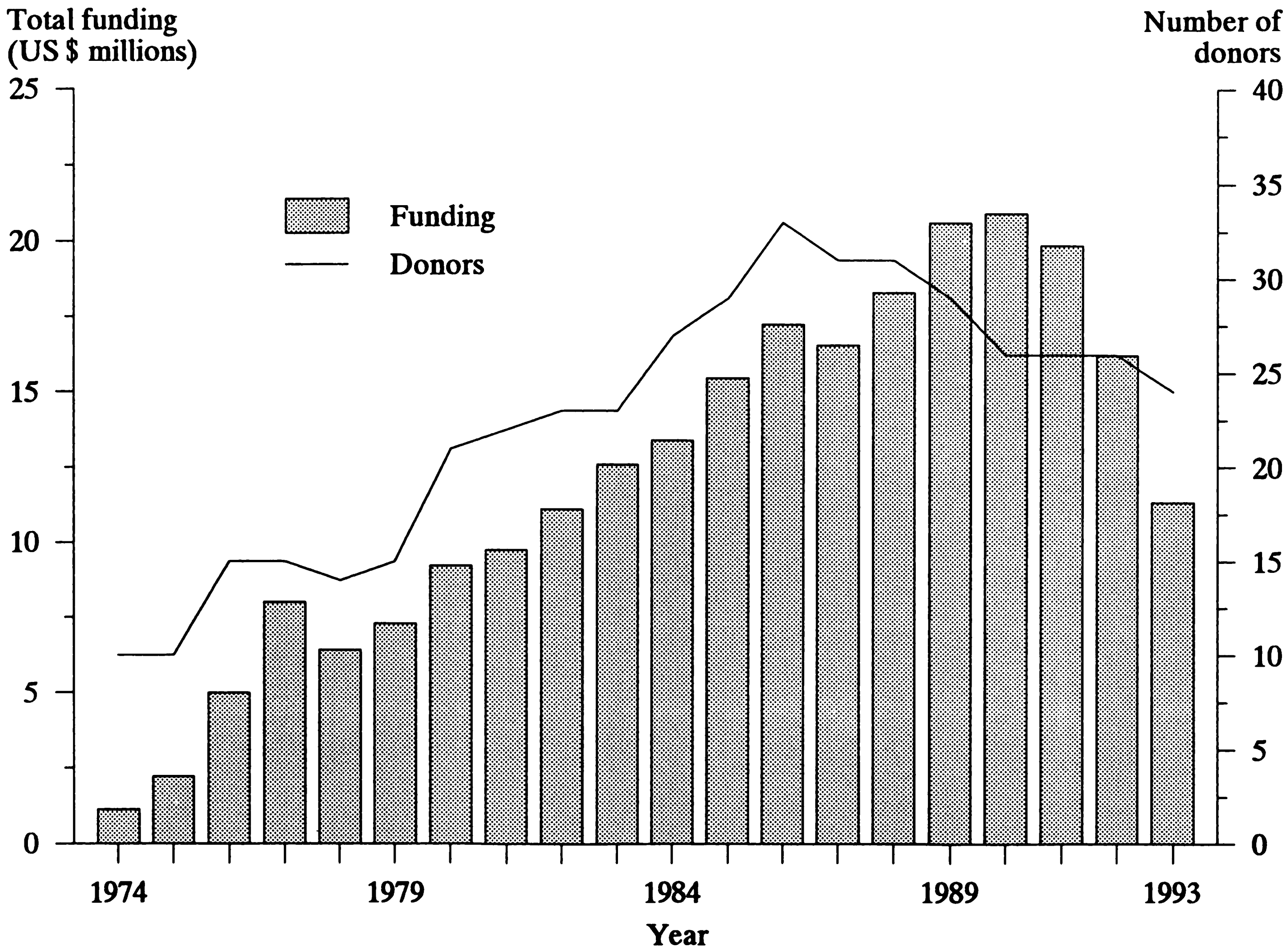
* Numbers indicate the number starting training at ILCA in each year (graduate and postdoctoral associates remain at ILCA for more than one year).

Major donors to ILCA, 1974–93

(Total donations exceeding US$ 100,000)

	Total funding (US$ '000)
United States Agency for International Development (USAID)	48,769
World Bank	47,179
Germany	20,057
Switzerland	17,488
Italy	12,635
Belgium	8,900
Canada	8,080
Norway	7,627
Finland	7,324
United Kingdom	6,692
Sweden	6,080
European Economic Community	5,400
Denmark	5,268
The Netherlands	5,180
Australia	4,631
France	4,072
International Fund for Agricultural Development (IFAD)	3,747
International Development Research Centre (IDRC)	3,684
Ireland	3,502
Nigeria	3,026
Japan	2,100
African Development Bank	1,530
Stabilization Fund	1,422
Austria	1,350
Norway	1,200
Iran	850
Office du développement de l'élevage de Mopti (ODEM)	800
Ethiopia	633
Oxfam US	464
Ford Foundation	403
Organization of Petroleum Exporting Countries (OPEC)	380
Caritas Switzerland	357
India	290
Tufts University	256
Botswana	241
Food and Agriculture Organization of the United Nations (FAO)/ International Board for Plant Genetic Resources (IBPGR)	171
Luxemburg	125
CARE-Ethiopia	114
Kenya	100

ILCA funding, 1974–93



Acronyms and abbreviations

AFRNET	African Feed Resources Network (ILCA/NARS)
AI	Artificial insemination
AVHRR	Advanced Very High Resolution Radiometer
BBF	Broadbed and furrow
BBM	Broadbed maker
CFA	Communauté financière africaine
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture, Colombia
CIMMYT	International Maize and Wheat Improvement Center, Mexico
CMS	Contract Mating Scheme, Kenya
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
DAP	Diammonium phosphate
DM	Dry matter
DNDF	Digestible neutral-detergent fibre
DTP	Desk-top publishing
EB	Ethiopian birr
ELISA	Enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization of the United Nations
FEC	Faecal egg count
FLDP	First Livestock Development Project, Botswana
FNE	Forage Network in Ethiopia
GDP	Gross Domestic Product
GTZ	German Agency for Technical Cooperation
IBPGR	International Board for Plant Genetic Resources, Italy
ICARDA	International Center for Agricultural Research in the Dry Areas, Syria
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
IDRC	International Development Research Centre, Canada
IITA	International Institute of Tropical Agriculture, Nigeria
ILRAD	International Laboratory for Research on Animal Diseases, Kenya
ITC	International Trypanotolerance Centre, The Gambia
INRZFH	Institut national de recherche zootechnique, forestière et hydrobiologique, Mali
IIASA	International Institute for Applied Systems Analysis, Austria
IVDMD	In vitro dry-matter digestibility
JIRDU	Jijiga Rangelands Development Unit
JVP	Joint Vertisols Project
KARI	Kenya Agricultural Research Institute
KLDP	Kenya Livestock Development Project

LME	Liquid milk equivalent
LTC	Land Tenure Center, University of Wisconsin-Madison, USA
MoA	Ministry of Agriculture
MPT	Multipurpose tree
NASA	National Aeronautics and Space Administration, USA
NDF	Neutral-detergent fibre
NDVI	Normalised difference vegetation index
NOAA	National Oceanic and Atmospheric Administration, USA
NPC	Net protection coefficient
ODEM	Office du développement de l'élevage de Mopti
OGAPROV	Office gabonais d'amélioration et de production de viande, Gabon
OM	Organic matter
PANESA	Pasture Network for Eastern and Southern Africa (ILCA/NARS)
PCV	Packed cell volume
PPR	Peste des petits ruminants
PTP	Progeny Testing Programme, Kenya
QQR	Quinquennial review
SDI	Selective dissemination of information
SLDP	Second Livestock Development Project, Botswana
TAC	Technical Advisory Committee of the CGIAR
TCRV	Tissue culture rinderpest vaccine
TGLP	Tribal Grazing Land Policy, Botswana
TLU	Tropical livestock unit
UHT	Ultra-heat treated
UNEP	United Nations Environment Programme, Kenya
USAID	United States Agency for International Development, USA

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